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A Revision of the Bee Genus *Calliopsis* and the Biology and Ecology of *C. andreniformis* (Hymenoptera, Andrenidae)[1]

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ABSTRACT

This is a taxonomic revision of the bee genus *Calliopsis;* information concerning distribution and biology is incorporated in the treatment of each species. *Calliopsis* occurs throughout North and Central America from southern Canada to southern Panama.

Four subgenera are recognized, including one new one: *Callopsima.* Thirty-eight species are included. One species is placed in synonymy; one is removed from synonymy; one is left as a *nomen nudum;* one is declared a *nomen dubium;* and two are transferred to other genera. About 7,000 specimens were examined.

Twenty-four new species are described: *C. granti, C. mourei, C. peninsularis, C. sonora, C. empelia, C. zora, C. helenae, C. rogeri, C. syphar, C. limbus, C. gilva, C. fulgida, C. yalea, C. rozeni, C. pectidis, C. timberlakei, C. unca, C. azteca, C. crypta, C. deserticola, C. hurdi, C. quadridentata, C. kucalumea,* and *C. micheneri.*

The biology and ecology of *Calliopsis andreniformis* were studied intensively at nesting sites in Lawrence, Kansas, and auxiliary observations were made on the species at Nacogdoches, Texas. It is primarily a summer bee which is active from May to September, and it forages mostly on legumes, especially alfalfa and clovers. It passes the winter underground as a prepupa. Emergence is in May about two weeks after the start of transformation to the pupa. Females typically make nest burrows in hard-packed clayey soil near or among clovers, and excavated soil is left as a closed mound on top of each burrow. The finished nest burrow of the female is a slanting, winding tunnel with one to ten short lateral burrows radiating around it at successively deeper levels. Each lateral burrow ends in a polished, waxed cell containing a spherical pollen ball within a thin, transparent membrane,

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and one frankfurter-shaped white egg atop it. The tunnel is four millimeters in diameter, and is up to 162 millimeters deep. In Kansas two generations per season are usual; in eastern Texas there are three generations.

A grid of squares each 30 centimeters on a side was fixed in place to cover two nesting areas of 41 square meters which included about 250 nests during one season. The succession of nesting phenomena, and physical and biotic factors were studied. Male and female burrows are aggregated in distinctly separate areas. Both sexes spend the night in their burrows, and marked individual males and females returned repeatedly to their same overnight burrows. The bees are active in winds up to 32 kilometers per hour, air temperatures of 27 to 40°C., and soil surface temperatures up to 54°C. The stimulus for daily emergence is a combination of soil temperature and soil moisture. Watered plots showed that rainfall increased burrowing activity.

Males patrol fairly well delineated areas. Each selects a resting place on the ground—a twig, stone, or leaf—and sets forth in a definite flight pattern, returning and alighting repeatedly at the same place. They often fly out of their flight pattern to make a sortie over nearby clover flowers. Mating takes place at the flowers or on the ground near the female burrows. An intruder in the male flyway is engaged in an aerial "dogfight," the two tumbling over each other, falling to the ground, kicking up dust, and biting one another. The intruder is repulsed. This is the first example of territorial behavior in the Andrenidae.

The female emits an odor of oil of lemongrass when slightly squeezed. The first mounds of female burrows contain this odor, but those of the males lack it. Experimentation suggests that its biological role is in aiding females to recognize their nest.

Parasites of *Calliopsis* are the bees, *Holcopasites calliopsidis, H. illinoiensis, H. arizonicus,* and *Sphecodes* spp.; the pyemotid mite *Trochometridium tribulatum;* and the molds *Penicillium cyclopium, Aspergillus flavipes,* and *A. sydowi.* An undetermined species of robber fly is a predator. *Bombylius ater* bombards with her eggs those open burrows where wind has blown away the tumulus, and bombyliid larvae were found in a few *Calliopsis* cells with no traces of the immature *Calliopsis.*

INTRODUCTION

The genus *Calliopsis* includes 38 described species of solitary, ground-nesting bees having white, cream or yellow areas on the head, legs, and mesosoma, and lacking such color on the metasoma. As the genus is currently interpreted, its species occur only, and are distributed widely, in North and Central America. Four subgenera are recognized and described. The state of the genus remained confused until Michener's decisive handling of it in Muesebeck, Krombein, and Townes (1951). In that publication numerous species of North America north of Mexico erroneously described as *Calliopsis* were transferred to their correct generic assignment. The only reliable published key to a circumscribed group of *Calliopsis* species is that of Mitchell (1960) which includes the three species known from the eastern United States. Other

keys are totally useless because 24 of the present species were unrecognized by the authors of the keys. Most of the original descriptions are inadequate in the light of present knowledge, and therefore all species are redescribed herein. The types deposited in the British Museum are unavailable to me, but excellent notes on certain characteristics of them have been furnished, on my request, by Padre J. S. Moure.

The investigation of the biology and ecology of *Calliopsis andreniformis*, the type species of the genus, was undertaken to form a frame of reference for similar work on other species. An attempt was made to collect meaningful data on diverse phases of the bee's biology and ecology so that even meagre data on other species would have a basis for comparison. The results of the investigation reveal striking resemblances to the biology of *Andrena, Perdita,* and *Nomadopsis* as discussed in appropriate places. My field observations have convinced me that *C. andreniformis* is potentially a valuable pollinator of small-flowered clovers, e.g., alfalfa. Its wide distribution, intense activity, great range of flowers visited, and the larger numbers in the field than museum collections indicate, all spell an important role for this species in the maintenance of native vegetation, especially among the Leguminosae and Compositae.

ACKNOWLEDGEMENTS

I express my thanks to Professor W. E. LaBerge who first drew my attention to Professor Charles D. Michener's interest in the *Calliopsis* problem (Professor Michener was in Brazil at the time). I am sincerely grateful to Professor Michener for initial outlining of the systematics and suggestions for the biological phase of the study, as well as his long-continued interest, encouragement, and specific help in preparation of the manuscript. To Padre J. S. Moure of the University of Paraná, Curitiba, Brazil, I am indebted for illuminating conversations which established the base for my understanding of the South American Panurgine genera which are closely allied to *Calliopsis*, and for the time generously spent in making tedious measurements and observations on *Calliopsis* types in the British Museum as mentioned above.

I am grateful also to the National Science Foundation for support of the behavioral parts of this study, through a grant (G11967) for Professor C. D. Michener to the University of Kansas, and to the Society of the Sigma Xi for a Sigma Xi-RESA Grant-in-Aid in the summer of 1958 which made possible comparative biological observations on *Calliopsis teucrii* and *Nomadopsis scitula* at Coaldale, Colorado.

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My cousin, Dr. Sylvia Earle Taylor, merits a special note of thanks for contributing the fine scratchboard drawings of *Calliopsis andreniformis* and *C. anomoptera*. To my sister, Mrs. Virginia S. Griggs, I am happy to extend thanks for aid in the exhaustive checking, ordering, and recording of collection data from the specimens used in the study.

Lastly, it gives me pleasure to acknowledge the moral and financial help of both my parents and my wife's parents in the last stages of the study, for without their aid the completion of the work would have been much delayed.

DISTRIBUTION

Ecologically, the distribution of the genus *Calliopsis* is virtually unknown. The bits of information available suggest a group which nests in hard-packed clayey soil less, usually much less, than 100 m from its pollen source. As exceptions to generalities, *C. (Verbenapis) nebraskensis* has been taken digging in sand dunes in Minnesota, and *Calliopsis andreniformis* was taken by my son, Roger, nesting in loam beside salt marshes at Hancocks Bridge, New Jersey, where it used the pollen of the Copper Mallow *(Malva neglecta)*.

Flower preferences are relatively pronounced for each subgenus, and differ among them. Although *Calliposis s.s.* is widely polylectic, it has been collected mostly on Leguminosae, especially the small-flowered clovers. *Perissander* occurs principally on Euphorbiaceae. *Calliopsima* is found primarily on the Compositae, particularly the Astereae and Heliantheae, with many records for *Heterotheca* and *Grindelia*. *Verbenapis,* as its name implies, is an oligolege of *Verbena*.

Perissander is apparently restricted to arid areas, but the other subgenera are amply represented in mountains, deserts, plains, and cultivated land, but not in heavily forested areas.

Seasonal distribution is somewhat different among the subgenera: *Calliopsis s.s.* has its peak activity soon after summer begins; *Verbenapis* shows maximum activity shortly afterwards, about midsummer; and *Perissander* and *Calliopsima* have their peaks in late summer. It should be borne in mind that these seasons, of course, occur at different calendar months depending

upon latitude and altitude. Table 1 gives the seasonal distribution of the species of *Calliopsis*.

TABLE 1. Seasonal Distribution of Species of *Calliopsis*

	Species	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1.	*andreniformis*				----	----	----	----	----	----	----		
2.	*teucrii*						----	----	----				
3.	*granti*								----				
4.	*rhodophila*					----	----	----	----	----			
5.	*mourei*						----						
7.	*squamifera*							----	----	----	----		
6.	*hondurasica*	----	----	----	----	----	----	----	----	----	----	----	----
8.	*peninsularis*									----			
9.	*sonora*								----				
10.	*empelia*								----				
11.	*zora*								----				
12.	*helenae*							----	----				
13.	*anomoptera*							----	----	----	----		
14.	*rogeri*								----	----			
15.	*syphar*									----	----		
16.	*limbus*							----	----				
17.	*gilva*								----	----			
18.	*fulgida*									----			
19.	*yalea*								----				
20.	*rozeni*				----	----	----	----	----	----	----		
21.	*coloradensis*						----	----	----	----	----		
22.	*pectidis*								----	----	----		
23.	*timberlakei*								----	----	----		
24.	*bernardinensis*								----	----	----		
25.	*unca*									----			
26.	*crypta*								----	----	----		
27.	*azteca*									----			
28.	*chlorops*							----	----	----			
29.	*coloratipes*							----	----	----	----		
30.	*deserticola*				----								
31.	*pugionis*				----	----	----	----	----				
32.	*hurdi*			----									
33.	*quadridentata*								----				
34.	*kucalumea*							----	----				
35.	*verbenae*				----			----	----	----			
36.	*nebraskensis*					----	----	----	----	----			
37.	*hirsutifrons*					----	----	----	----				
38.	*micheneri*			----	----								

Geographically, the genus occurs from coast to coast in North America and from latitude 50° North in Canada to latitude 8° North in Panama. No specimens are known from the northwestern United States and adjacent Can-

ada, viz., northern California, Oregon, Washington, and British Columbia. There is a similar lack of specimens from El Salvador, British Honduras, and Nicaragua, presumably because of lack of collecting.

Calliopsis s.s. and *Calliopsima* are represented throughout the range of the genus. The distribution of *Perissander* is limited to southeastern Arizona and the Sonoran Desert in México, Arizona, California, and Baja California. *Verbenapis* has been collected only about Mexico City northward to New Mexico and Texas and in the plains states east of the Rocky Mountains with an isolated population from northern New Jersey. I expect it will eventually be found in most of the eastern United States.

The richest concentration of species in each of the subgenera occurs in México or the arid southwestern United States. These regions are well known for their diverse habitats and abundant opportunities for geographic isolation.

PHYLOGENY AND SYSTEMATICS

There is no fossil record of these bees nor is there such a record for any panurgine bee. This situation forced an interpretation of phylogenetic relationships deduced from species at one level in time, and this interpretation is based primarily upon comparative morphology of the adults supplemented by the available distributional data. The resultant diagram of relationships is given in Fig. 1.

In Fig. 1 the species *syphar* and *yalea* are depicted with a relationship to

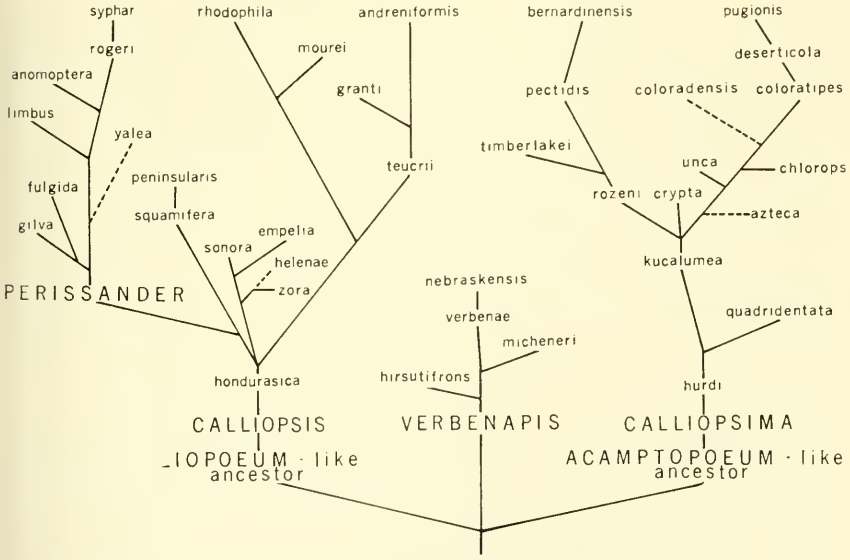


Fig. 1. Diagram of relationships of the genus *Calliopsis*.

Perissander. I believe they belong there, but this will only be determined upon discovery of the males. A dashed line indicates uncertainty.

Four genera of panurgine bees are closely related to *Calliopsis: Nomadopsis, Hypomacrotera, Acamptopeum,* and *Liopoeum*. Rozen (1951) has shown that the generic limits of these bees are questionable, and I agree with him. Various combinations of presumably important characters which appear in *Calliopsis* are found in these allied genera. The unsettled status of the genera makes it impossible to state which subgenera of *Calliopsis* have more primitive characters, and, moreover, it is not possible to make decisions upon which species within a subgenus are more primitive than others because particular specializations in each species are counterbalanced by other specializations in other species. This is the same predicament encountered by Rozen (1958) in his revision of *Nomadopsis*.

Three main types of male genitalia are represented among, and are characteristic of, the subgenera of *Calliopsis,* as explained below.

Type 1, *Calliopsis s.s.* and *Perissander:* penis short, thick; penis valve about twice penial length, in form of a thin, broad sheet which is usually wider medially, convex dorsally with intricate folds, lines, and thickenings, and hollowed ventrally; volsellae small, well-separated, knoblike or lobelike. See Figs. 8-57.

Type 2, *Calliopsima:* penis long, slender; penis valve narrow, tubular, slightly exceeding length of penis, having an expanded, flattened, dorsally directed terminal portion; volsellae large, well-separated, elongate. See Figs. 58-122.

Type 3, *Verbenapis:* penis long, thick; penis valve narrow, medio-ventrally concave, terminal portion directed dorsally, tip bent toward mesal line; volsellae small with projections so close as to give the impression of a single structure. See Figs. 123-143.

Primarily on the basis of a study of the genitalia and sterna of panurgine bees which are likely relatives of *Calliopsis,* I have concluded that the genera most closely related to it are the North American *Nomadopsis* and *Hypomacrotera,* and the South American *Acamptopoeum* and *Liopoeum*. The superficially somewhat similar South American genera *Spinoliella, Callonychium,* and *Arhysosage* (=*Ruiziella* Timberlake) do not belong in the same group. *Hypomacrotera* and *Micronomadopsis* parallel *Calliopsis s.s.* in male genitalia and sterna, yet are closer to *Verbenapis* on the basis of external characteristics.

The diagnosis excludes all panurgine genera except the South American *Acamptopoeum* Cockerell and some species of *Liopoeum* Friese. This is deliberately contrived because until a thorough review of the classification of the panurgine genera closely related to *Calliopsis* is completed, I am inclined to favor the possibility suggested by Michener (1944:246) that the "South

American genus *Parafriesea=Acamptopoeum* . . . is probably a mere subgenus of *Calliopsis*." I believe the species included by J. S. Moure (1956, personal communication) in *Liopoeum* represent more than one genus, but those considered by him to be *Acamptopoeum* are a clearcut group of closely related species. The differences and similarities among the subgenera of *Calliopsis* seem to be of the same order of magnitude as those between *Acamptopoeum* and any one of them. In any event, if my interpretation of the content of *Calliopsis* presented herein proves acceptable, then surely *Acamptopoeum* must fall as a subgenus of the older *Callopsis*. Padre Moure, however, would unhesitatingly accord generic rank to *Calliopsis s.s., Calliopsima, Perissander,* and *Verbenapis* (1957, personal communication). With such a classification, *Acamptopoeum* would also be of full generic rank. An investigator's position on a problem like this depends upon personal psychology, philosophy, and taste.

Species from South America which most closely resemble the genus *Calliopsis* as herein constituted are *Liopoeum hirsutulum* Friese, 1908 (not Spinola, 1851), and two apparently undescribed species of *?Liopoeum* (one may be *Camptopoeum laetum* Vachal) from Argentina. The latter two species may prove eventually to represent yet another group intermediate among *Calliopsis s.s., Calliopsima, Liopoeum,* and *Acamptopoeum*. Color patterns and head dimensions of *Calliopsima* are similar to those of *Acamptopoeum*. *Verbenapis* is most similar, among South American bees, to *Liopoeum trifasciatum* (Spinola, 1851); a number of important external characters are shared. These are, for example, placement of cream areas on face in the female; shape of face; presence of a few *curled hairs* on front tarsomeres 2-4; similar propodeum; and similarly shaped and sloped metasomal tergum 1. The genitalic pattern of *L. trifasciatum* is that of *Calliopsis s.s.,* however, although three or four metasomal terga bear yellow maculae. *Liopoeum* is a more likely progenitor of *Nomadopsis* than is *Spinoliella*. No counterparts of *Perissander* are known to me from South America.

The absence of closely related forms in the Palearctic region and the paucity of species in the northern and eastern United States, together with the numerous closely related forms from South America, argue for an origin of *Calliopsis* in South America with migrations northward through Central America and Mexico to the United States and Canada.

Taxonomically useful characters at the subgeneric level were relatively few with the females, but included hair color of the prepygidial and pygidial fimbriae; length of mouthparts; sculpture of the dorsal enclosure of the propodeum; extent of light color on the paraocular area; and relationships among the minimum interocular distance, clypeocellar distance, and flagellar length. The most reliable and hence the most useful bases for subgeneric groups, as well as for discrimination of species, were the male genitalia and sterna 5, 6, 7,

and 8. Other useful ones for subgeneric grouping of the males were length of mouthparts, sculpture of the dorsal enclosure of the propodeum, extent of light color in the paraocular areas, color of subantennal plates, and presence or absence of scutellar and metanotal hair pads. No reliable differentiating character was found for the females of *Perissander;* the male must be known to make a positive subgeneric assignment.

Considerable difficulty was experienced in finding reliable characters to separate females of several closely related species. The most important criterion in every such case was the sculpture of the dorsal enclosure of the propodeum or the punctation and ground character of the integument of the scutum and metasomal terga 1 and 2.

The bases for the matching of the sexes, among sympatric species, are primarily the similarity of the punctation of the scutum and of metasomal terga 1 and 2 and the striking resemblance of the mouthparts other than the mandibles. Matching of the sexes proved troublesome in the case of the species *crypta* and *rozeni*. Most students of the wild bees assume that the capture of male and female bees *in copulo* is virtually proof that they are the same species. The following paragraph, however, shows that this may not be the case.

Initial analysis of the species in *Calliopsima* led me to group females of *chlorops, crypta,* and *rozeni* all under *chlorops*. This grouping was based on too few specimens for the recognition of *crypta* and *rozeni*. Specimens received recently have clarified the status of the three species involved. J. G. Rozen and G. I. Stage, both competent collectors, supplied mating pairs of *Calliopsis* including a male of *rozeni* in each case. Rozen's pair, however, included a female different from the one in Stage's pair. On the basis of the close similarity of both punctation and vestiture of Stage's male and female, I concluded that they were the same species and that Rozen's female represented *crypta*. Is it possible that females of these sympatric species resemble each other so closely that their respective males may make an error in identity and copulate with the wrong female?

Characters useful at the specific level included various quantitative dimensions and ratios among them, as well as qualitative characters, as noted in the keys and taxonomic treatments of the species. The black or dark brown integumental color is subject to fading, e.g., the female type of *teucrii* was described as "black . . . clypeus entirely black . . . tegulae shining piceous. . . ." The specimen is now brown to light brown. Fading is equally striking in older specimens of *chlorops, coloradensis, nebraskensis,* and *verbenae,* among others. The white, cream, or yellow maculations do not seem to change in quality. Because of fading, differences in darkness of ground color are described only in extreme cases, and the integument is to be taken as dark, nonmetallic, for all species unless otherwise described.

DESCRIPTIVE TERMINOLOGY AND METHODS

Abbreviations. These are held to a minimum and include the following:

2-5, 1-4, 9-wt, etc. Read as "2 to 5 inclusive, 1 to 4 inclusive," or "distance from position 2 to position 5, distance from position 9 to position wt," etc.

mio=minimum interocular distance.

mm=millimeter(s).

mow=middle ocellar width(s).

N.A.=not available, used where a structure cannot be examined or measured, usually because of its absence, the fragility of the specimen, or the unavailability of the specimen to me.

pwa=puncture width(s) apart.

S.W.R.S.=Southwestern Research Station of the American Museum of Natural History, 5 miles west of Portal, Chiricahua Mountains, Cochise County, Arizona.

wing, 12-13/13-14=forewing, the ratio of the distance between 12 and 13 to the distance between position 13 and 14 (cf. Fig. 5).

Terminology. The terminology followed in the systematic portion of the paper is basically that of Michener (1944). An explanation or equivalent of certain terms which are used in this work or have been used in older works treating *Calliopsis* species is given below. The terms used here are italicized.

apicotarsus: collective term for the last four tarsomeres; used in apposition to basitarsus.

light coloration on the subantennal plates=dog-ear marks (Cockerell).

dorsal enclosure of the propodeum=disc of metathorax (Robertson)=horizontal (usually somewhat declivous) enclosure of the propodeum=basal, or upper, portion of the propodeal triangle. It differs markedly from the remainder of the propodeal triangle by its sculpturing.

eccentric punctures=punctures deviating from radial symmetry in being shallow at one end, becoming deeper with a vertical, or nearly vertical, wall at the other end.

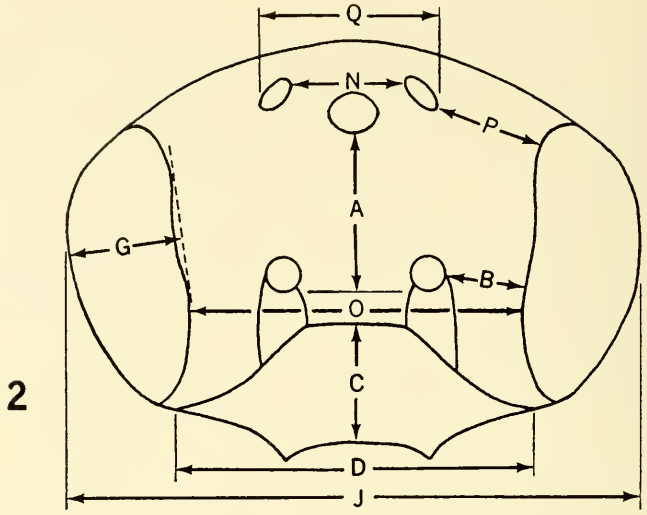
galeal gap=the distance between the tip of the galea in repose and the base of the prementum.

-mere=suffix used with tarsus and flagellum to designate real or apparent segments, e.g., tarsomere.

orbital convergence ratio=the ratio of the middle ocellar interocular distance (at the level of the lower border of the middle ocellus, Fig. 3,T) to the minimum interocular distance. It is used as a measure of the degree of ventral convergence of the inner orbits.

pebbled=a type of integumental sculpturing which resembles the surface of pebble-grained leather.

pronotal lobes=tubercles=the lobelike, dorsolateral projections of the pronotum.



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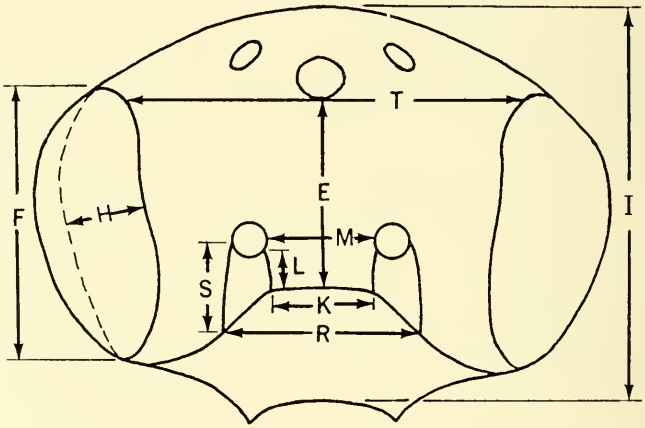

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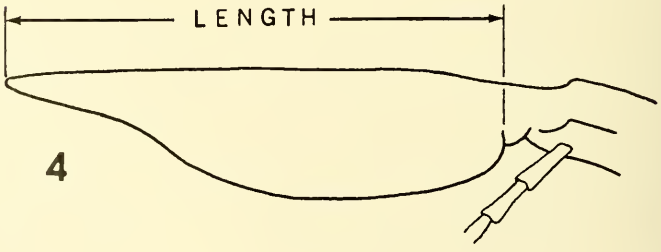

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propodeal flats=the posterolateral faces of the propodeum, immediately adjacent to the propodeal triangle, where such faces are relatively plane, sometimes medially convex, areas.

scutellar and *metanotal hair pads*=calluslike areas of mesoscutellum and metanotum of certain *Calliopsis* males (Timberlake)=well-defined patches of dense, extremely short, profusely branched—hence mosslike—pubescence, which occupy, respectively, the depression between the disc of the scutellum and the base of the hind wing, and the lateral portions of the metanotum.

scutellum=mesoscutellum.

scutum=mesoscutum=thoracic dorsulum (Cockerell).

sternum=metasomal sternum, where unqualified.

tergum=metasomal tergum.

Measurements. Head and galeal measurements are shown in Figs. 2-4.

All measurements are given in millimeters and were made at 30× magnification with a Bausch & Lomb StereoZoom(R) Microscope and an ocular micrometer with each micrometer unit equal to 17 microns or 0.017 mm. The precision of the decimal ratios can be inferred from the number of digits given, the last digit being the doubtful one.

Lengths of scutum, scutellum, metanotum, and propodeum are measured along the median longitudinal line. The intertegular distance is the minimum distance measured transversely across the scutum between the edges of the concavities of the thorax which receive the tegulae. Forewing length is length including tegula. Hindwing length is from the junction of the wing with the thorax to the wing tip. It is as good an indicator of general body size as the forewing.

The forewing of a male *Calliopsis andreniformis* is illustrated in Fig. 5. An arbitrary numbering system was used in the analysis of similarities and differences of the wings within and among species. Lengths of wing veins were measured from the midpoints of the vein intersections shown. The length of the marginal cell was taken as the maximum length measured between the *inside* edges of the bordering veins. Distance from the tip of the marginal cell to the wing tip was measured at 9-wt (Fig. 5).

Abdominal width is the maximum width and invariably occurs on metasomal tergum 3.

Figs. 2-4. Measurements of head and galea. 2-3: A, frontal line; B, antennocular distance, minimum; C, clypeal length, median; D, clypeal width, the lateral limit usually mesal to the lowest point on the orbit; E, clypeocellar distance; F, eye length; G, eye width, facial view; H, eye width, basal, the straight line distance between anterior and posterior orbital margins; I, head length; J, head width, maximum; K, inner subantennal sutural distance, minimum; L, inner subantennal suture, vertical length; M, interantennal distance; N, interocellar distance; O, interocular distance, minimum; P, ocellocular distance, minimum (=ocellocular line); C + E, ocellolabral distance; Q, outer ocellar distance; R, outer subantennal sutural distance; S, outer subantennal suture, vertical length; T, interocular distance at level of median ocellus. 4: Galea, lateral view, showing measurement of length.

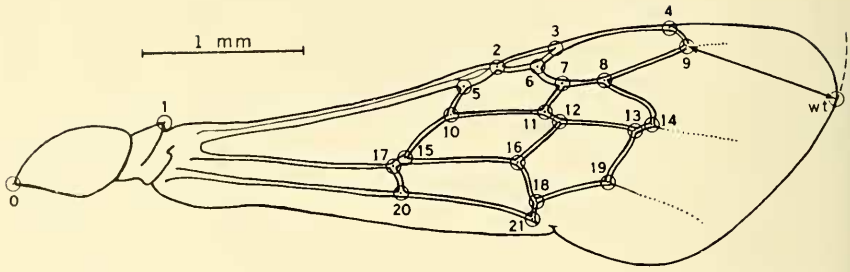


FIG. 5. Forewing of male *Calliopsis andreniformis*. Wing dimensions are obtained by measuring point to point, 0-wt, wing length including tegula; 1-2, length of vein C; 2-3, length of stigma; 2-5, length of prestigma; 2-6, length of stigma from base to vein r; 3-4, length of marginal cell (=2nd R_1) along costal margin of wing; 3-4-9, length of vein R_1; 5-10, basal side of 1st submarginal cell (=1st abscissa of R_s); 6-7, length of crossvein r; 6-9, length of marginal cell; 7-8, length of costal side of 2nd submarginal cell (=2nd abscissa of R_s); 8-9, length of free part of marginal cell (=3rd abscissa of R_s); 10-11, length of posterior side of 1st submarginal cell (=R_s+M); 10-15, length of basal vein (=1st abscissa of M); 11-12, distance from 1st transverse cubital or intercubital to 1st recurrent vein (=2nd abscissa of M); 11-14, length of posterior side of 2nd submarginal cell (=2nd to 4th abcissae of M); 12-13, distance between anterior ends of recurrent veins (=3rd abscissa of M); 12-16, length of first recurrent vein (=1st m-cu); 13-14, distance between transverse cubital and 2nd recurrent veins (=4th abscissa of M); 13-19, length of 2nd recurrent vein (=2nd m-cu); 15-16, length of 1st abscissa of Cu; 15-17, distance from cu-v to basal vein; 15-18, length of Cu; 16-18, length of 2nd abscissa of Cu; 17-20, length of transverse medial crossvein (=cu-v); 18-19, length of Cu_1; 18-21, length of Cu_2; 20-21, length of 2nd abscissa of V.

The word "distance" as well as the dimensional units are usually omitted from various facial and body measurements to save needless repetition, and where units are not specified they are millimeters, e.g., "clypeocellar 0.85" means that the clypeocellar *distance* is 0.85 mm.

Basitarsal length in *Verbenapis* is measured along the lateral median line and hence excludes the ventral apical prolongation present in this subgenus; basitarsal length in the other subgenera is measured from extreme base to apex which includes any apical prolongation present.

NOTES ON TECHNIQUES. In various places a magnification is specified for an observation by placing it in parentheses following the observation. For example, "facial fovea shiny, unsculptured (15×)." This is done because terms such as shiny, impunctuate, polished, unsculptured, etc., are sometimes applicable only within a certain range of magnification, and the above statement, while true, might also read "facial fovea dull, roughened (120×)."

Optimum lighting is diffused daylight, and the Bausch & Lomb Fluorescent Illuminator used in this study yielded 500 foot candles of illumination at the specimen. Integumental punctation and propodeal sculpture will be obscured or distorted for some species with undiffused light.

Accurate measurements of mouthparts may occasionally be necessary. Where relaxation in a moist chamber followed by manual manipulation failed to extend the mouthparts as desired, I used the following method: relaxed specimen in a moist chamber; dissected away mouthparts and placed them in

cold lactophenol solution; brought to boiling point and held there until structures extended; rinced in hot glycerin; allowed to cool; transferred to fresh glycerin for measurements. This method has worked on specimens 80 years old.

The same technique produces cleared genital and sternal preparations which retain their deposited melanins and fine hairs. I find this superior to the caustic potash treatment except that occasionally the genital capsule has entrapped air which, on expansion and escape, tears the capsule.

Descriptions. The description of a new species is based upon the holotype and allotype with parenthetical notes referring to paratypes which differ significantly from the type. Variation of other specimens is discussed under Remarks or Geographic Variation.

Redescription of a previously described species is treated in a similar manner when the type(s) is available. Otherwise the redescription is based on metatypes, homotypes, notes made on types by a reliable hymenopterist, topotypes, or the most representative specimen among all available, with parenthetical notes referring to specimens which differ significantly from the described specimen.

The initial part of the description of each sex of a species gives measurements which are general indicators of the size of the bee. Least reliable is the length of the bee, because it is dependent upon the degree of extension of both head and metasomal terga. Clypeal length is the measurement showing the highest correlation with the length of the bee.

A number is given to each character or group of characters described for each subgenus and each species. This numbering is used to facilitate comparisons among the taxa. Where a particular number is absent for a given species, the character is not of comparative importance for the subgeneric or species group in which the species occurs.

Descriptions of the species ordinarily omit verbal treatment of the genitalia and sterna because the illustrations are adequate in themselves. Details of those which are of particular significance in separation of closely allied species are designated by an arrow on the illustration which points to the diagnostic feature.

Detailed collection data are given for new species, but such data are given only for the uncommon redescribed species.

Distributional maps depict the known range of each species. Collections and biological data are too few to attempt prediction of the total range of most species. Each symbol for a species represents one or more specimens collected at that locality, and in some cases represents several collections made at nearby localities. This procedure is justified on a small scale map provided that the collections so plotted are from similar localities. Of course, every locality is listed in the written treatment.

TAXONOMIC TREATMENT

Genus CALLIOPSIS Smith

Type species. Calliopsis andreniformis Smith, 1853, by designation of Ashmead, 1889, Trans. Amer. Ent. Soc. 26:85.

Diagnosis: (a) American panurgine bees with white, cream or yellow integumental markings on head, mesosoma, and their appendages, on a black ground, metasoma without such light markings; (b) marginal cell truncate apically, its length along costal margin of wing beyond apex of stigma subequal to or less than distance from its tip to tip of wing, except in *anomoptera;* (c) two submarginal cells, lengths along posterior margins subequal; (d) second submarginal cells along longitudinal axis of wing much longer than broad; (e) middle tarsus of male longer than hind tarsus; (f) horizontal portion of propodeum impunctate with various sculptural patterns or smooth and shiny with depressions; (g) metasomal terga with conspicuous, although not necessarily complete, bands of light hair along posterior margins (1×).

Female. Length 5-10 mm. Integument sculptured or smooth, unsculptured (120×).

Head. Integumental background color black, occasionally metallic. Light colored areas: (1) paraocular area; (2) clypeus; (3) labrum, sometimes absent; (4) supraclypeal area, except usually absent in *Verbenapis;* (5) subantennal plate, often absent, and variable intraspecifically; (6) mandible, basal position, or absent, tip reddish or reddish brown. (7) Scape, pedicel, and dorsal surface of flagellomeres 1-4 brown to black, ventral surface usually much lighter with darker color of flagellomeres 1-3 (sometimes 4) encircling part way ventrad, flagellomeres 5-10 of uniform color ventrally. (8) Hair of head variable from black to white, but hair of gena always white. (9) Punctures usually finer than in corresponding male. (10) Puncture size and density variable. (11) Frontal line with lower portion moderately elevated, narrowly sulcate, rarely weakly carinate. (12) Clypeus evenly convex or with lower half of disc flattened or medially concave, slightly to strongly protuberant beyond anterior edge of eye in profile. (13) Inner orbits convergent below: orbital convergence ratio 1.05-1.30. Facial fovea shallow, indistinct to deep, distinct; narrow, linear to broad, ovoid. (14) Galea variable in length, shape, and sculpture; galeal gap absent to about 3.8 mow. Glossa cylindrical, flabellate (flat, truncate, flabellum absent in *squamifera, peninsularis,* and *anomoptera* group of subgenus *Perissander.* (15) Head width/head length, 1.2-1.5. (16) Median apical border of clypeus below orbit by 0.5-1.3 mow. (17) Ratios of eye length, mio, and flagellar length variable. (18) Interocellar, ocellocular, antennocular, interantennal variable with respect to each other. (19) Ocellolabral subequal to or greater than clypeal width. (20) Clypeocellar greater than outer subantennal sutural. Outer subantennal sutural 2 times or

more length of inner subantennal sutural. (21) Basal labial palpomere from 1.5-6.0 times length of others combined. (22) Flagellomere 1 longer than 2, 2 shorter than 3, 3 shorter than 4. Flagellum with maximum width subequal to mow. Flagellar length 1.8-2.8 times length of scape, relatively uniform within a subgenus.

Mesosoma. (23) Integumental background color black, occasionally metallic. Light colored areas: medially interrupted stripe along posterior dorsal border of pronotum except in *Verbenapis;* pronotal lobe, often; scutellar crest, often. (24) Scutal and scutellar hair variable in length, density, and color. Mesepisternal hair white, usually longest of mesosoma, flowing, with numerous minute branches. Posterior half of scutellum with many long, erect hairs. Metanotal hair white to fulvous, with long, medial hairs directed posteriorly but curving upward apicad. A narrow strip of white to fulvous, densely branched, minute hairs clustered along scutellar crest. Metanotum with similar strip along posterolateral border, of greater extent, hair sparser, longer. Scutellar and metanotal hair pads absent or obsolete. Propodeal hair white. (25) Scutal disc with punctures and character of interspaces variable. (26) Dorsal enclosure of propodeum completely smooth to variously sculptured, only rarely with a few punctures. (27) Legs with light color usually the same as on face. Foreleg with light coloration. (28) Middle leg with light coloration. Spur no more than 0.8 times basitarsal length, pectination variable (absent in *squamifera*). (29) Hind leg dark except in the closely related species *pectidis, timberlakei,* and *bernardinensis*. (30) Tegula usually transparent, at least posteriad, often with anteroapical patch of light color. Humeral plate white to brown. (31) Wing iridescent, colorless or faintly smoky to brown in the apical region beyond cells. Costal vein progressively darker apicad. Subcostal vein brown, darkest in the wing. Stigma slightly wider, or narrower, than prestigma, width including costal vein in both cases. (32) Marginal cell 6-9 and 3-4 variable with respect to 9-wt, see Fig. 5.

Metasoma. (33) Integumental background color of terga black (except orange to reddish on some terga of *anomoptera*), occasionally with metallic tints, of sterna black to brown. (34) Tergal hair bands white or fulvous, denser laterad. Band of tergum 1 usually sparse or interrupted medially. Suberect hair of discs of terga 4-5 black to white. Prepygidial and pygidial fimbriae smoky to white. (35) Tergum 1 with punctures variable. (36) Tergum 2 with punctures of median area finer, denser than tergum 1. Pygidial plate present, distinct, narrowly rounded apically. (37) Sternal color testaceous to black, light coloration absent. Sternum 6 usually with a median, clear (rarely extremely dark) circular or subcircular area in the apical sclerotized portion (indistinct in some specimens).

Male. Length, 4-9 mm. Integument as in female.

Head. Integumental background color as in female. Light colored areas:

(1) paraocular area; (2) clypeus, except for narrow, testaceous to black apical border and two tiny, testaceous to black wedge-shaped marks always present near dorsolateral corners of median portion; (3) labrum, rarely absent; (4) supraclypeal area (sometimes absent in *Verbenapis*); (5) subantennal plate (absent in *Verbenapis*); (6) as in female. (7) As in female but of lighter hue than corresponding female. (8,9,10) As in female. (11) Frontal line with lower portion moderately to strongly elevated, either narrowly sulco-carinate or sharply carinate. (12) As in female. (13) Inner orbits more strongly convergent below than in female: orbital convergence ratio about 1.15-1.45. Facial fovea obsolete to distinct; smaller than that of female; shape similar to that of female. (14) As in female. (15) Head width/head length about 1.10-1.50. (16, 17) As in female. (18) Interocellar variable with respect to ocellocular, both greater than either antennocular or interantennal; antennocular greater than interantennal. (19,20,21) As in female. (22) As in female but flagellomere 1 sometimes subequal to or shorter than 2. Flagellum with maximum width subequal to mow. Flagellar length 2.8-4.2 times length of scape.

Mesosoma. (23) As in female except all subgenera exclusive of *Verbenapis* have some species with more or less extensive light color on sterna. (24) Scutal, scutellar, mesepisternal and metanotal hair similar to that of female. Scutellar and metanotal hair pads present in *Calliopsis s.s.*, absent in other subgenera. (25,26) As in female. (27) Legs with light color usually the same as on face. Foreleg with more extensive light coloration than in female. (28) Middle leg with more extensive light coloration than in female. (29) Hind leg with much more extensive light coloration than in female except in *Verbenapis* where leg may be completely brown or have only basitibial plate with light coloration. (30,31,32) As in female.

Metasoma. (33,34) As in female. (35) Tergum 1 with punctures of median area as in female but rarely sparse. (36) As in female but often less distinct. (37) As in female but rarely with some yellow. (38) Genitalia without gonostyli, penis not fused with penis valves. Sterna and genitalia distinctive for the subgenera as described.

DISCUSSION. The diagnosis excludes the distantly related genus *Perdita* by the combination of characters (b,c,d), and usually (a); the closely related *Nomadopsis* by the combination of (a,b,g); and the equally closely related *Hypomacrotera* by the combination of (b,e,g).

KEYS TO THE SPECIES OF *Calliopsis*

The following keys are separated by sexes because of dimorphism in all species. Every attempt was made to avoid characters requiring dissection, but this was not always possible. The section on Descriptive Terminology and Methods should be consulted before use of the keys, with special attention be-

ing given to the part on measurements. It has been possible for the most part to place related species together, and this should help in the final determination which might have to be based upon the description of the species.

The male terminalia are illustrated by drawings which portray their average condition, but minor variations are to be expected. In some instances, an arrow points to a particularly significant condition which is mentioned in the keys or in the descriptive treatment of the species.

Males

1. Dorsal area of propodeum unsculptured, highly polished, with median depression with longitudinal, low ridge giving impression of twin pits; subantennal plates black (subgenus *Verbenapis*) 2

   Dorsal area of propodeum sculptured, or, if polished, lacking kind of depression described above; subantennal plates variable in color 5

2(1). Tegula with opaque white patch on outer anterior portion; pygidial plate with sides at angle of less than 35°, length of margined portion of plate about 2.0 times width at base; depth of incision between lobes of sternum 6 twice width of a lobe ..... *micheneri*

   Tegula without white coloration; pygidial plate with sides at angle of 40° or more, length of margined portion of plate less than 1.5 times width at base; depth of incision between lobes of sternum 6 equal to or less than width of a lobe 3

3(2). Hind basitarsus light brown to dark brown; elevation bordering anterior edge of posterior depressed margin of metasomal tergum 1 absent medially (use 20× or less); punctures of medial area of dorsum of tergum 1 finer than mesoscutal punctures, mostly 2 or more pwa ..... *nebraskensis*

   Hind basitarsus whitish or cream colored; elevation bordering anterior edge of posterior depressed margin of metasomal tergum 1 entire; punctures of medial area of dorsum of tergum 1 as large or larger than mesoscutal punctures, mostly 1-2 pwa .. 4

4(3). Clypeus entirely cream colored with two small brownish triangular clypeal dots; supraclypeal area usually with a cream dot; eye length exceeding minimum interocular distance; hindwing length 2.7-3.3 mm. ..... *hirsutifrons*

   Clypeus cream colored except for triangular brown dorsolateral corners; supraclypeal dot absent; eye length less than minimum interocular distance; hindwing length 3.5 mm. or more ..... *verbenae*

5(1). Without velvety patches of dense, short, moss-like hairs on the lateral portions of the scutellum and metanotum *(Perissander* and *Calliopsima)* 6

With velvety patches of dense, short, moss-like hairs on the lateral portions of the scutellum and metanotum (*Calliopsis* s.s.) 10

6(5). Sternum 6 with a pair of long, mesolateral, posteriorly directed, directed, subacicular processes; ratio of length of middle tibia to length of middle basitarsus less than 0.95; mesopleural punctures very fine, some indistinct, mostly more than 2 pwa; galea usually not exposed beyond closed mandibles, but may extend as much as 1 mow in *gilva;* penis valve broad, width one-third or more of length; penis short, scarcely reaching to midlength of penis valve *(Perissander)* 7

Sternum 6 with a pair of short, mesolateral, variously directed, variously shaped (but never subacicular) processes; ratio of length of middle tibia to length of middle basitarsus greater than 1.00; mesopleural punctures large, deep, distinct, mostly less than 2 pwa; galea always exposed beyond closed mandibles, length exposed usually more than 2 mow; penis valve narrow, width about one-eighth of length; penis long, almost reaching apex of penis valve *(Calliopsima)* 18

7(6). At least terga 1-3 reddish orange; forewing with tip bent abruptly posteriad and drawn out into a rounded apex (Fig. 5) ..... *anomoptera*

Terga 1-3 black, or black with metallic tints; forewing with tip normal (Fig. 4) 8

8(7). Thoracic dorsum and terga 1-4 with brassy tints (30×); wing tip distinctly brown to the naked eye; sternum 8 in ventral view with apical portion paddle-shaped, the paddle portion about as long as broad ..... *rogeri*

Thoracic dorsum and terga 1-4 without metallic tints (30×); wing tip clear to smoky to the naked eye; sternum 8 in ventral view with apical portion distinctly longer than broad 9

9(8). Scutal punctures with smooth, shiny interspaces (30×); hind tarsomere 2 cylindrical to club-shaped in dorsal view; eye length about one-sixth greater than mio ..... *gilva*

Scutal punctures with interspaces roughened; hind tarsomere 2 equilaterally triangular in dorsal view; eye length subequal to mio ..... *limbus*

10(5). Scape with ventral surface largely yellow 11

Scape with ventral surface entirely dark 15

11(10). Scape entirely yellow, except sometimes with a small triangle of light brown with base at mesolateral apex of scape, apex of triangle attenuate ventrally and not reaching middle of scape; metanotal hair pads dark brown to black (pale brown in Baton Rouge, La., specimen), small, separated by 3 mow; hind femur often with a brown patch posteriorly .. *andreniformis*

Scape partly yellow on ventral surface and sometimes on dorsal surface, too, with at least a large area of the mesolateral apical corner brown or black (if brown area is apparently small, then flagellum much longer than head); metanotal hair pads tan or gray, or if brown then separated by less than 1 mow; hind femur yellow 12

12(11). Tegula with a yellow patch; tiny species with hindwing length (or forewing 1-9) from 1.90 to 2.30 mm ..... *squamifera*

Tegula brown; larger species with hindwing length (or forewing 1-9) 2.63 mm, or larger 13

13(12). Metanotal hair pads tan to pale brown, separated by more than 3 mow ..... *hondurasica*

Metanotal hair pads brown or gray, separated by less than 1 mow 14

14(13). Flagellar length subequal to head length, about one-fifth longer than head width, about 3.5 times scape length; metanotal hair pads brown; Sonora, Mexico ..... *sonora*

Flagellar length about one-fourth longer than head length, subequal to head width, about 4.0 times scape length; metanotal hair pads gray; southeastern Arizona ..... *empelia*

15(10). Integument with metallic cobalt blue tints on dark frons, vertex, and thoracic dorsum, and metallic green tints on metasomal terga; light markings of face, pronotal lobe, and interrupted posterior pronotal stripe, white or cream color; light markings of legs yellow; state of México ..... *mourei*

Integument either non-metallic or with brassy tints especially on lower frons, vertex and thoracic dorsum, and with or without brassy tints on metasomal terga; light markings of face, pronotal lobe, interrupted posterior pronotal stripe, and legs concolorous, yellow 16

16(15). Metanotal hair pads ligulate, confined to metanotum, separated by two-thirds or more mow ..... *teucrii*

Metanotal hair pads large, subquadrate or oval, covering dorsal propodeum, contiguous, at least posterioly 17

17(16). Integument black; scutellar hair pads separated by less than 2 mow; metanotal hair pads subquadrate; galea aciculate,

smooth, shiny, length exposed beyond closed mandibles about three times galeal gap; punctures of disc of scutum fine, about 2 pwa, interspaces smooth ..... *rhodophila*

Integument black with brassy tints, especially on head and thoracic dorsum; scutellar hair pads separated by more than 2 mow; metanotal hair pads oval; galea narrowly rounded but not aciculate, uniformly pebbled, length exposed beyond closed mandibles subequal to galeal gap; punctures of disc of scutum larger, about 1 pwa, interspaces shiny but finely roughened, more so anteriad ..... *granti*

18(16). Pedicel with anterolateral surface yellow; scape entirely yellow or at most with brown apical rim or brown line on posterior surface; all coxae with at least a spot of yellow about half the area of median ocellus 19

Pedicel brown (1 specimen of *bernardinensis* with anterolateral surface yellow); scape, posteriorly and at least mesoapical corner anteriorly, brown; all coxae brown, or at most a tiny patch of yellow on the fore coxae 20

19(18). Scape entirely yellow or at most with light brown apical rim; ratio of maximum length of middle tibia to maximum length of middle basitarsus 1.00-1.08; scutal punctures not visible from directly above because of profuse branching of dense, short (about 1 mow), hairs (30×); punctures of scutal disc mostly less than 1 pwa ..... *pectidis*

Scape yellow except for brown apical rim and narrow brown triangle with apex attenuated toward base of scape on posterior surface; ratio of maximum length of middle tibia to maximum length of middle basitarsus 1.11-1.29; scutal punctures visible from directly above, hairs with very short branches, longer (mostly 2 mow) (30×); punctures of scutal disc mostly 1-2 pwa ..... *timberlakei*

20(18). Scape entirely brown to black 21

Scape with yellow on anterior surface 25

21(20). Front apicotarsus yellow; marginal cell 6-9 about one-sixth to one-fifth longer than 9-wt. 22

Front apicotarsus brown; marginal cell 6-9 about one-fourth to one-third longer than 9-wt. 23

22(21). Expanded midlateral portion of metasomal sternum 8 bearing sharp points at posterior corners; posteroventral projections of base of genital capsule small, short, rounded ..... *chlorops*

Expanded midlateral portion of metasomal sternum 8 smoothly

rounded at posterior corners; posteroventral projections of base of genital capsule large, long, sharply pointed ..... *crypta*

23(21). Tegula with yellow macula; tip of humeral plate yellow; expanded midlateral portion of metasomal sternum 8 smoothly rounded at posterior corners; anterior surfaces of front and hind tibiae entirely yellow; genital capsule with four posteroventral projections from base ..... *quadridentata*

Tegula without yellow macula; humeral plate entirely brown; expanded midlateral portion of metasomal sternum 8 bearing sharp (sometimes tiny!) points at posterior corners; anterior surfaces of front and hind tibiae with large areas of brown; genital capsule with two posteroventral projections from base 24

24(23). Outer surface of hind basitarsus brown; basal labial palpomere with length 3 or more times combined length of remaining palpomeres (1.14:0.36); length of galea exposed beyond closed mandibles about 4 times galeal gap ..... *hurdi*

Outer surface of hind basitarsus yellow with brown border; basal labial palpomere less than 2.6 times combined length of remaining palpomeres (0.78:0.34); length of galea exposed beyond closed mandibles less than 2 times galeal gap ..... *kucalumea*

25(20). Twin mesolateral posterior projections of metasomal sternum 6 flat (readily observable on intact specimens) 26

Twin mesolateral posterior projections of metasomal sternum 6 bent distinctly ventrad thus forming a pair of short to rather long prongs 28

26(25). Front and middle apicotarsi bright yellow; anterior surface of hind tibia yellow; anterior surface of hind basitarsus yellow, often with partial or complete brown border ..... *rozeni*

Front and middle apicotarsi testaceous to brown; anterior surface of hind tibia half or more brown; anterior surface of hind basitarsus brown 27

27(26). Length of galea exposed beyond closed mandibles 3.0-4.5 times galeal gap; interantennal more than 1.8 times galeal gap; mow less than maximum flagellar diameter; tegula and tip of humeral plate with yellow maculation; Colorado Desert .... *deserticola*

Length of galea exposed beyond closed mandibles less than 2.5 times galeal gap; mow greater than maximum flagellar diameter; tegula and humeral plate brown; southwestern California ..... *pugionis*

28(25). Hair bands of metasomal terga 1-4 complete, dense, snow-white, hairs erect with somewhat decumbent apices, profusely branched, integument below bands not or barely visible from

above; punctures of entire middle third of metasomal tergum 1 uniformly crowded, about one-third pwa; metasomal sternum 7 with median portion broad apically (Fig. 78); southwestern California ..... *bernardinensis*

Hair bands of metasomal terga 1-4 never all complete, hairs sparse, whitish, appressed, branches virtually nonevident (30×), integument below readily visible from above; punctures of entire middle third of metasomal tergum 1 not uniformly crowded, more than one-half pwa; metasomal sternum 7 with median portion narrowed apically (Fig. 59); not known from California 29

29(28). Fore tibia with posterior surface yellow or yellow at apex and base with a patch of brown medially; hind tibia with posterior surface yellow or yellow with a median patch of brown, rarely brown patch at tibial apex 30

Fore tibia with posterior surface brown or brown except for basal area subequal to 2 times area of median ocellus; hind tibia with posterior surface brown or brown with yellow outer margin widening into a yellow basal area 32

30(29). Dorsal surface of metasomal tergum 1 with a wide, impunctate, shiny area 0.5-1 mow in length adjacent to upper rim of anterior declivity ..... *azteca*

Dorsal surface of metasomal tergum 1 punctate all the way to upper rim of anterior declivity 31

31(30). Medial half of dorsal enclosure of propodeum with ridges strongly vermiform; punctures of dorsal median fifth of metasomal tergum 1 large, deep, distinct, contiguous; volsella with posterolateral corner bent sharply dorsad, hence called "hooked"; metasomal sternum 6 with lateral margin at base of each posterorior projection slightly swollen (Fig. 84) ..... *unca*

Medial half of dorsal enclosure of propodeum with ridges straight or slightly bowed; punctures of dorsal median fifth of metasomal tergum 1 small, usually shallow, often eccentric 0.5 or more pwa; volsella with posterolateral corner not "hooked"; metasomal sternum 6 with lateral margin at base of each posterior projection not swollen (Fig. 64) ..... *coloradensis*

32(29). Hind tibia with posterior surface all brown; metasomal sternum 6 with lateral margin at base of each posterior projection slightly swollen (Fig. 88) ..... *crypta*

Hind tibia with posterior surface brown with a yellow border along outer margin usually widening into a yellow area basad;

metasomal sternum 6 with lateral margin at base of each posterior projection not swollen 33

33(32). Dorsal surface of metasomal tergum 1 with a wide, impunctate, shiny area 0.5-1 mow in length adjacent to upper rim of anterior declivity ..... *azteca*

Dorsal surface of metasomal tergum 1 punctate all the way to upper rim of anterior declivity 34

34(33). Metasomal tergum 1 with large, coarse punctures less than 1 pwa laterad; about 8 punctures per 0.01 mm^2 in middle of tergum; dorsal enclosure of propodeum with a carinate posterior border, median portion of about 1 mow with quite vermiform ridges, remaining ridges longitudinal, relatively straight .. *chlorops*

Metasomal tergum 1 with small, fine punctures mostly more than 1 pwa, about 10 punctures per 0.01 mm^2 in middle of tergum; dorsal enclosure of propodeum with at most a weak carina only along median portion of posterior border, median portion of about 1 mow with longitudinal ridges relatively straight and similar to remaining ridges ..... *coloratipes*

Females

1. Dorsal area of propodeum unsculptured, highly polished, with median depression with longitudinal, rounded ridge giving the impression of twin pits; subantennal plate black or dark brown (subgenus *Verbenapis*) 2

Dorsal area of propodeum sculptured, without such a depression; subantennal plate variable in color 5

2(1). First metasomal tergum with a shallow concavity in median dorsal area, sharply sloped anteroventrally; punctures of median dorsal area of tergum 1 very few, 3 or more pwa on a very shiny ground; metasomal tergum 2 with a distinct median convex bump; fore basitarsus, ratio length/width, 3.5-4.5 ..... *nebraskensis*

First metasomal tergum without such a concavity, the dorsal area a smooth, continuous curve from side to side; punctures of median dorsal area abundant, 2 or less pwa on a moderately shiny ground; metasomal tergum 2 without a distinct median convex bump; fore basitarsus, ratio length/width, 5.5 or more 3

3(2). Mandible with basal half brown or black, or with a tiny, indistinct yellowish spot at extreme outer base; dorsal median margin of clypeal cream coloration straight or shallowly concave ..... *verbenae*

Mandible with basal fourth to half cream colored; dorsal median margin of clypeal cream coloration strongly convex upward 4

4(3). Tegula transparent dark brown; hindwing length less than 3.6 mm; fore basitarsus, ratio length/width, 8.0-9.5 ..... *hirsutifrons*

Tegula transparent smoky straw color with opaque cream maculation anteriorly; hindwing length equal to or more than 4.0 mm; fore basitarsus, ratio length/width, 4.5-5.5 ..... *micheneri*

5(1). Prepygidial and pygidial fimbriae smoky, reddish-brown, or black; disc of metasomal terga 3-5 bearing numerous short, black hairs 6

Prepygidial and pygidial fimbriae fulvous or white; disc of metasomal terga 3-5 bearing fulvous or white hairs 23

6(5). Galea in repose extending beyond closed mandibles 1.25 mow or more 7

Galea in repose extending beyond closed mandibles 1 mow or less (*Perissander,* and *Calliopsis s.s.* in part) 15

7(6). Medium sized species, hindwing length 3.80 mm or less, mio less than 1.36 mm; maxillary palpomere 2 shorter than, or at most equal to maxillary palpomere 3 (30×); lateral portion of clypeus brown to black *(Calliopsis s.s.)* 8

Large sized species, hindwing length 3.90 mm or more, mio more than 1.50 mm; maxillary palpomere 2 distinctly longer than maxillary palpomere 3 (30×); lateral portion of clypeus yellow (*Calliopsima,* in part) 32

8(7). Tegula with at least a dot of yellow 9

Tegula without yellow, straw color to black 10

9(8). Disc of scutum with fine punctures more than 1 pwa, interspaces shiny, becoming only faintly roughened anteriorly; flagellar length subequal to mio; yellow area of tegula larger than median ocellus; Texas, Coahuila ..... *helenae*

Disc of scutum with coarse punctures 1 pwa, interspaces shagreened, becoming strongly roughened anteriorly; flagellar length one-sixth shorter than mio; yellow area of tegula smaller than median ocellus; southeastern Arizona ..... *empelia*

10(8). Galea highly polished, tapered to a sharp point (20×), length exposed beyond closed mandibles about 3 mow; metasomal tergum 1 highly polished with very fine, sparsely distributed punctures about 3 pwa on the disc, posterior area impunctate (20×) ..... *rhodophila*

Galea lightly pebbled, at least on apical fourth, and tapered to a blunt, rounded tip, length exposed beyond closed mandibles 1.5-2.5 mow; metasomal tergum 1 dull, or if polished, then

punctures fairly evenly distributed, usually 2 or less pwa on disc, posterior area punctate (20×) 11

11(10). Scutum and metasomal tergum 1 with ground dulled by abundant fine roughening; basal labial palpomere with stout setae ventrally; frons without brassy, metallic tints (*hondurasica* group, in part) 12

Scutum and metasomal tergum 1 with ground smooth, sometimes shiny, or if roughened, then roughening confined to anterior portion of scutum; frons with weak, brassy, metallic tints 14

12(11). Hairs of stipes straight or slightly curved from bases to apices; punctures of scutum coarse; less than 0.5 pwa on disc with punctures becoming much more crowded anteriorly ..... *zora*

Hairs of stipes, at least many of them, more or less abruptly bent over at the tip, frequently curled at the tip; punctures of scutum fine, mostly more than 1 pwa with punctures becoming somewhat more crowded anteriorly 13

13(12). Flagellar length about one-tenth longer than mio; larger species, hindwing length about 3.5 mm, head length 1.62 mm or more, intertegular 1.39 mm or more ..... *hondurasica*

Flagellar length subequal (one-twentieth more or less) to mio; smaller species, hindwing length about 2.9 mm, head length 1.53 mm or less, intertegular 1.33 mm or less ..... *sonora*

14(11). Declivity of metasomal tergum 1 with a dull, satiny surface; punctures of disc of metasomal tergum 1 fine, shallow, with moderately shiny interspaces, actual diameter about 8 μ or less, 2 pwa on anterior portion of dorsum; Rocky Mountain states, southeastern Canada, central and eastern United States ..... *andreniformis*

Declivity of tergum 1 finely lineolate with a high polish; punctures of disc of metasomal tergum 1 fine, deep, with highly polished interspaces, actual diameter about 12 μ, 1 pwa on anterior portion of dorsum; central Mexico, Arizona, New Mexico, Colorado ..... *teucrii*

15(6). Mesotibial spur, untoothed (60×) 16

Mesotibial spur with at least 2 apical teeth 17

16(15). Mesotibial spur three-fourths or more of length of middle basitarsus; middle tibial length subequal to middle basitarsal length; Arizona ..... *squamifera*

Mesotibial spur less than 0.6 times length of middle basitarsus; middle tibial length 0.3 times longer than middle basitarsus; Baja California ..... *peninsularis*

17(15). Mesotibial spur with 2-4 coarse teeth on apical 0.4, the basal 0.6 perfectly bare ..... *gilva*
Mesotibial spur with 7 or more fine teeth 18
18(17). Metasomal terga 1-4 largely orange or reddish-orange .. *anomoptera*
Metasomal terga 1-4 black or metallic brassy 19
19(18). Scutum with all interspaces between punctures finely, distinctly roughened; marginal cell 6-9 less than 9-wt; ratio of length of flagellum to length of scape, 2.6-2.8 ..... *limbus*
Scutum either with all interspaces between punctures smooth, or only roughened anteriorly; marginal cell 6-9 more than 9-wt; ratio of length of flagellum to length of scape, 2.0-2.4 20
20(19). Smaller species, hindwing length (forewing 1-9 gives same measurement) 2.0-2.7 mm; median portion of dorsal enclosure of propodeum with fine lines originating posteriorly, fanning out anterolaterally toward base of propodeum 21
Larger species, hindwing length (forewing 1-9 gives same measurement) 3.0 mm or larger; dorsal enclosure of propodeum not as above 22
21(20). Brassy, metallic colored integument on frons, scutum, scutellum, and metasomal terga ..... *rogeri*
Black or dark brown integument on frons, scutum, scutellum, and metasomal terga ..... *syphar*
22(20). Mesotibial spur with 6-8 teeth; facial fovea long, linear, 4-5 times longer than wide, deeply impressed with distinct lateral margin; posterior portion of metasomal tergum 1 with mirror-like polish, virtually impunctate; southeastern Arizona and southwestern New Mexico ..... *fulgida*
Mesotibial spur with about 15 teeth; facial fovea moderately long, broader at midlength, 3-4 times longer than wide, shallowly impressed with relatively indistinct lateral margin; posterior portion of metasomal tergum 1 shiny, completely punctate; Michoacan ..... *yalea*
23(5). Tibiae with dorsal or anterior surfaces mostly yellow 24
Tibiae with dorsal surfaces bearing yellow color only at extreme bases 25
24(23). Scutal hair dense, appearing nap-like (10×) and obscuring punctation because of its profuse, relatively long, branches; scutal length one-tenth or more greater than eye length; front basitarsal length equal to or greater than front apicotarsus ..... *pectidis*
Scutal hair thin (10×) with punctures readily visible; scutal

length subequal to eye length; front basitarsal length about one-tenth shorter than front apicotarsus ..... *timberlakei*

25(23). At least basal fifth of mandible brown or black 26

At least basal fifth of mandible yellow or cream color 28

26(25). Both long and short scutal hairs fulvous 27

Long scutal hairs brown, short ones fulvous ..... *crypta*

27(26). Metasomal tergum 1 with large, deep, punctures, sparser medially ..... *rozeni*

Metasomal tergum 1 with very fine punctures, not sparser medially, often denser medially ..... *coloradensis*

28(25). Metasomal tergum 1 with punctures very dense, crowded medially, less than 0.5 pwa, about 11 punctures per 0.01 mm^2 of median area ..... *bernardinensis*

Metasomal tergum 1 with very sparse punctures, from 0-3 punctures per 0.01 mm^2 of median area 29

29(28). Labrum brown; the two lateral brown bars of median disc of clypeus joined by a strip of brown at least along dorsal side of preapical groove of clypeus; facial light color a deep, rich lemon yellow ..... *pugionis*

Labrum cream color, pale yellow, or rarely, mostly brown; the two lateral brown bars of median disc of clypeus not joined; facial light color cream or very pale yellow 30

30(29). Punctures of metasomal tergum 1 moderately large, usually sparse medially, but may be rather regularly spaced medially becoming sparser laterally; horizontal enclosure of propodeum distinctly longer medially than laterally, bearing longitudinally vermiform ridges which are fairly readily distinguishable from each other (30×) ..... *chlorops*

Punctures of metasomal tergum 1 very fine, always sparser medially than laterally, interspaces highly polished; horizontal enclosure of propodeum with median third of about equal length throughout, bearing either straight, longitudinal ridges well separated from each other, or densely packed, very fine, longitudinally vermiform ridges difficult to distinguish from each other (30×) 31

31(30). Disc of clypeus with tiny, twin, wedge-shaped, light brown spots or very light brown, narrow bars; basal labial palpomere one-tenth to one-fifth shorter than clypeocellar ..... *coloratipes*

Disc of clypeus with large, twin, dark brown bars; basal labial palpomere one-tenth to one-fifth longer than clypeocellar ..... *deserticola*

32(7). Largest species of the genus, hindwing length 4.9 mm; basal

labial palpomere one-sixth longer than clypeocellar; forewing 3-4 about one-tenth less than 9-wt; disc of metasomal tergum 1 finely roughened ..... *hurdi*

Moderately large species, hindwing length 3.8-4.4 mm; basal labial palpomere subequal to clypeocellar to one-tenth less; forewing 3-4 subequal to or less than 9-wt; disc of metasomal tergum 1 smooth, shiny ..... *kucalumea*

Subgenus CALLIOPSIS Smith

Calliopsis Smith, 1853, Catalogue of Hymenoptera in the British Museum 1:128; Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric., Monogr., No. 2:1103; Mitchell, 1960, North Carolina Agric. Exp. Sta. Tech. Bull. No. 141:288-294.

Type species. Calliopsis andreniformis Smith, 1853, by designation of Ashmead, 1899, Trans. Amer. Ent. Soc., 26:85.

This subgenus is closer to *Perissander* than to the other subgenera. Its closest South American relatives seem to be apparently unnamed Argentinian species of *Liopoeum*. Two groups of species fall together rather naturally: the *andreniformis* group, including *teucrii, mourei, rhodophila, wilda,* and *helenae;* and the *hondurasica* group, including *sonora, empelia, squamifera, peninsularis,* and probably *zora.*

This is the most widespread subgenus. It occurs from Panamá to Canada, and from the eastern United States west to Utah and southwest to Nevada, California, and the tip of Baja California Sur. The species favor Leguminosae, especially *Trifolium, Melilotus, Medicago,* and *Psoralea,* with next choices being Verbenaceae and Compositae.

Calliopsis differs from the other subgenera in the male by the prominent scutellar and metanotal hair pads, and in the female by the combination of the length of galea exposed beyond closed mandibles being greater than 1 mow (except in *squamifera*), the prepygidial and pygidial fimbriae being smoky to dark reddish brown, and in both sexes by the tumid paraocular area.

FEMALE. Length, 5.0-7.5 mm.

Head. Yellow areas: (1) paraocular area below a line originating between middle of outer subantennal suture and near upper end of suture and extending diagonally upward ending on orbit approximately at level of upper rim of antennal socket, usually below level of facial fovea (above in *helenae*), or yellow area reduced to small patch along orbit; lower inner paraocular area adjoining junction of frontoclypeal suture and outer subantennal suture tumid, most strongly in *andreniformis,* least in *hondurasica;* (2) clypeus with a median longitudinal band originating at frontoclypeal suture, ending at or slightly above clypeal apex; lateral areas brown except in *helenae* and some *rhodophila* which have several blotches of yellow; (3) absent on labrum except on apex of labral plate in *zora* and *helenae;* (4) supraclypeal area pen-

tagonal or semilunar with apex approximately at midlevel of antennal socket; (5) subantennal plate highly variable from totally dark to totally light (6) absent on mandible. (7) Scape and pedicel black, ventral surfaces of flagellomeres 1-2 black, of 3-4 black with median portions tan, of remaining ones tan; dorsal surface of basal flagellomeres dark brown, flagellomeres becoming progressively lighter brown apicad. (8) Hair of vertex mixed colorless and light brown, or mixed fulvous and dark brown, of frons white or fulvous, of clypeus pale brown to black and coarser than on other areas, of gena white. (10) Punctures along ocellocular line fine, interspaces variable; impunctate area lateral to posterior ocellus shiny to exceedingly dulled by roughening; punctures of frons with interspaces sometimes metallic, shiny to very dull (30×). (11) Frontal line with lower portion a narrow sulcus rising gradually to a summit on frontal prominence between antennal sockets slightly above their midline. (12) Clypeus with punctures of disc somewhat eccentric, or at least with sloping sides like a volcano cone. Clypeus with disc convex medially. Projections beside median apical emergination of clypeus pointed. (13) Inner orbits slightly convergent below. Facial fovea shallow to deep, linear to broadened medially and narrowed at both ends. (14) Galeal length variable, length of galea exposed beyond closed mandibles variable from absent to within 1 mow of base of prementum. (15) Head width/head length 1.25-1.60. (17) Eye length variable with respect to mio, but equal to or less than flagellar length (except much greater in *empelia*), and subequal to outer subantennal sutural. (18) Interantennal to antennocular variable, interantennal less than 2 mow. (19) Ocellolabral equal to or greater than mio. (21) Basal labial palpomere 1.5-3.8 times length of others combined. (22) Flagellomere 1 with length variable with respect to flagellomere 9. Flagellar length 1.8-2.5 times length of scape.

Mesosoma. (23) Light colored areas: medial interruption of pronotal stripe 1-4 mow; apex of pronotal lobe; scutellar crest. (24) Scutal and scutellar hairs of two kinds, longer ones fulvous to brown, shorter ones fulvous. (25) Scutal disc with punctures usually distinct, interspaces highly polished to extremely dulled by minute roughening. (26) Dorsal enclosure of propodeum variously sculptured, always with some longitudinal ridges. (27) Legs with light color the same as on face. Foreleg with basal spot of yellow on tibia, and sometimes on extreme apex of femur. (28) Middle leg with basal spot of yellow on tibia, sometimes on extreme apex of femur; spur with many fine teeth (bare in *squamifera*). (29) Hind leg brown. (30) Tegula brown, with anterior yellow spot in some species. Humeral plate brown. (31) Wing smoky apically beyond cells. Stigma brown. (32) Marginal cell 6-9 subequal to, or longer than, and 3-4 shorter than 9-wt.

Metasoma. (34) Tergal hair bands white to fulvous (orange fulvous in some *andreniformis*), dense, appressed. Band of tergum 1 broadly inter-

rupted, of tergum 2 narrowly interrupted; other tergal bands entire (all at 10×). Suberect hair of discs of terga 4-5 dark brown to black. Prepygidial and pygidial fimbriae smoky to dark brown. (35) Tergum 1 with punctures of median area variable, uniformly to irregularly distributed to partially impunctate; interspaces exceedingly dull to highly polished; punctures smaller than on scutum. Declivity of tergum 1 usually finely lineolate, somewhat dull (shiny in *rhodophila* and most specimens of *teucrii*).

Male. Length, 4.0-6.5 mm.

Head. Yellow areas (white in *mourei* and *squamifera*): (1) paraocular area below a relatively straight, or a dorsally convex line, from upper outer edge of antennal rim tangent to or slightly indented by lower end of facial fovea, ending on orbit at or slightly above lower end of facial fovea; lower half of paraocular area tumid, most strongly so near junction of outer subantennal suture and frontoclypeal suture; (2) clypeus except a clear to black border on lateral portion of apex; frontoclypeal suture yellow to black; (3) labrum, except for 3 small circular or subcircular clear to black spots, one in each laterobasal corner and a median one approximately in center of labral plate; (4) supraclypeal area apex from slightly below midlevel of antennal socket to about 0.5 mow above upper edge of socket; (5) subantennal plate except sometimes black near junction of outer subantennal suture and frontoclypeal suture; (6) mandible basal fourth or more, some species with anterior and posterior border brown to black. (7) Scape and pedicel all yellow, yellow and brown, or all black; flagellomeres as in female, except some species with yellow on ventral surface of first two or three flagellomeres, remainder having successively more tan toward apex of flagellum. (8) Hair of vertex variable, of frons white or fulvous, of clypeus colorless, fulvous, brown, or black. (10) Punctures of face variable. (11) Frontal line with lower portion a sharp high carina or a relatively low, extremely finely sulcate carina. (12) Clypeus with punctures of disc as in female except finer; median portion strongly protuberant, usually protruding 0.17 mm or more in front of eye in lateral view. (13) Inner orbits strongly convergent below. Facial fovea usually with ill-defined mesal border. (14) Galeal length and length of galea exposed beyond closed mandibles as in female, galeal gap greater than inner subantennal sutural, but less in *rhodophila*. (15) Head width/head length 1.15-1.38. (17) Eye length greater than mio, considerably less than flagellar length. (18) Interantennal greater than antennocular, and less than 2 mow. (21) As in female. (22) As in female except flagellar length about 3.0-4.1 times length of scape.

Mesosoma. (23) As in female. (24) Scutal and scutellar hair all light, or in some species with longer hair brown, other hair as in female. Scutellar hair pads well developed, never contiguous, composed of densely packed, short, profusely branched hairs occupying lateral portion of scutellum, sometimes part of median portion also. Metanotal hair pad much greater in extent

than on scutellum, contiguous medially in *granti* and *rhodophila*. (25) Scutal disc with punctures as in female. (26) Dorsal enclosure of propodeum variously sculptured, with at least some longitudinal ridges which may be somewhat vermiform or reticulate. (27) Legs with light color the same as on face except in *mourei* and *squamifera*. Foreleg color pattern variable. (28) Middle leg color pattern variable. (29) Hind leg color pattern variable. (30) Tegula brown, with anterior yellow spot in *squamifera* and rarely in *andreniformis*. Humeral plate brown. (31) Wing as in female but tip much darker, pale brown. Stigma as in female. (32) Marginal cell 6-9 subequal to or greater than, and 3-4 equal to or less than 9-wt; 11-12 shorter than 13-14.

Metasoma. (34) As in female but hair bands much less dense. (35) As in female but size of punctures variable with respect to scutal punctures. Declivity of tergum 1 variable. (36) Pygidial plate ill-defined, disc irregularly concave, usually with median apical emargination. (37) Sterna brown to black (rarely, with median preapical yellow spot in *andreniformis*). Sternum

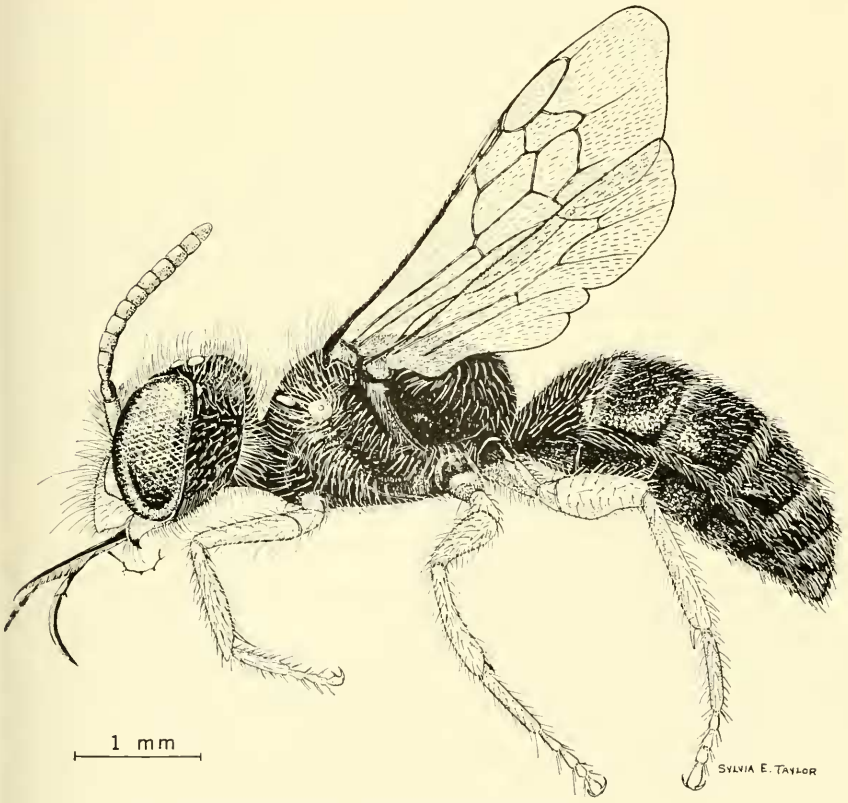


Fig. 6. Lateral view of male *Calliopsis (C.) andreniformis* Smith.

5 produced posteriorly into a long, tapered point. Sternum 6 with apical margin produced into a pair of long, aciculate, spine-like processes. Sternum 8 with a relatively broad, apical paddle-like portion. (38) Sterna and genitalia as illustrated (Figs. 8-45).

CALLIOPSIS (CALLIOPSIS) ANDRENIFORMIS Smith

(Figs. 5,6,8-13; Map 1)

Calliopsis andreniformis Smith, 1853, Catalogue of Hymenoptera in the British Museum, 1:128, female; Cockerell, 1897, Canad. Ent., 29:290; Cockerell, 1898, Trans. Amer. Ent. Soc., 25:196; Robertson, 1898, Trans. Acad. Sci. St. Louis, 8:48; Ashmead, 1899, Trans. Amer. Ent. Soc., 26:85 (type species of *Calliopsis*); Bridwell, 1899, Trans. Kansas Acad. Sci., 16:210; Cockerell, 1899, Ent. News, 10:3; Graenicher, 1905, Bull. Wisconsin Nat. Hist. Soc., 3:159; Lovell and Cockerell, 1906, Psyche, 13:113; Swenk and Cockerell, 1907, Ent. News, 18:178; Cockerell, 1909, Ann. Mag. Nat. Hist., (8)4:28; Tucker, 1909, Trans. Kansas Acad. Sci., 22:282; Smith, 1910, Ann. Rep. New Jersey State Mus. 1909: 691; Graenicher, 1911, Pub. Mus. City Milwaukee Bull., 1:238; Crawford, 1913, Canad. Ent., 45:271; Gibson, 1913, 44th Ann. Rep. Ent. Soc. Ontario: 20; Viereck, 1916, *in* Britton, Connecticut Nat. Hist. Surv. Bull., 22:722; Washburn, 1919, Minnesota Agric. Exp. Sta., Jour. series, No. 156:229; Stevens, 1919, Canad. Ent., 51:210; Britton, 1920, Connecticut Geol. Nat. Hist. Surv. Bull. 31:345; Rau, 1922, Trans. Acad. Sci. St. Louis, 24(7):33; Robertson, 1922, Psyche, 29:168; Reinhard, 1924, Ann. Rep. Smithsonian Inst., 1922, Publ. Number 2738:371-373 (biol.); Lovell, 1925, Maine Naturalist, 5:7; Leonard, 1926, Cornell Univ. Agric. Exp. Sta. Mem., 101:1021; Robertson, 1926, Psyche, 33:118 (biol.); Robertson, 1928, Flowers and Insects, p. 10+(biol.); Hendrickson, 1930, Iowa State Coll. Jour. Sci., 4(2): 163 (biol.); Pearson, 1933, Ecol. Monogr., 3:387, 409-11, 418 (biol.); Graenicher, 1935, Ann. Ent. Soc. Amer., 28:303; Cockerell, 1936, Amer. Mus. Novitates, 831:3; Ainslie, 1937, Canad. Ent., 69(5): 97-100 (biol.); Brimley, 1938, Insects of North Carolina, p. 453; Procter, 1938, Biological Survey of the Mount Desert Region [Maine], 6:442 and 1946, 7:504 (biol.); Lovell and Lovell, 1939, Rhodora, 41:185 (biol.); Timberlake, 1947, Pan-Pac. Ent. 23:29; Crandall and Tate, 1947, Jour. Amer. Soc. Agronomy, 39:161-163 (biol.); Michener, 1947, Amer. Midl. Nat., 38:477; Stevens, 1950, North Dakota Agric. Exp. Sta. Bimonthly Bull., 12:93-94; Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric. Monogr. No. 2:1103; Rozen, 1951, Jour. Kansas Ent. Soc., 24:142; Mitchell, 1956, Jour. Elisha Mitchell Sci. Soc., 72(2)207 (biol.); Montgomery, 1957, Proc. Indiana Acad. Sci., 66:129 (biol.); Wille, 1958, Ann. Ent. Soc. Amer., 51(6):544 (anat.); Mitchell, 1960, North Carolina Agric. Exp. Sta. Tech. Bull. No. 141:288-289, 291-294; Byers, 1962, Jour. Kansas Ent. Soc., 35:320 (biol.).

Calliopsis flavipes Smith, 1853, Catalogue of Hymenoptera in the British Museum, 1:128, male.

Calliopsis lepidus Cresson, 1878, Trans. Amer. Ent. Soc., 7:68, female; Cockerell, 1898, Trans. Amer. Ent. Soc., 25:196; Cresson, 1916, Mem. Amer. Ent. Soc., 1:122.

Panurgus vernalis Provancher, 1882, Nat. Canad., 13:204; 1883, Faune entomologique du Canada, Hyménoptères, 704.

Calliopsis flavifrons; Banks, 1912, Ent. News, 23:107 (misidentification).

Calliopsis rhodophila; Stevens, 1919, Canad. Ent., 51:210 (misidentification).

The female of *andreniformis* was considered to resemble females of the genus *Andrena,* hence its name. Its closest relative is *C. teucrii.* The male of *andreniformis* is distinguished readily from that of *teucrii* by its entirely yellow scape, whereas that of *teucrii* is brown. The female of *andreniformis* is distinguished from *teucrii* only with difficulty. The anterior slope of metasomal tergum 1 has a satiny sheen on the surface in *andreniformis* but has a finely lineolate polish in *teucrii;* the integument of the anterior portion of the dorsum of the scutum is brassy colored in *andreniformis,* non-metallic in *teucrii.*

Female. Length, 7.0 mm (type 7.4 mm); forewing length, 4.8 mm (type 5.0 mm); hindwing length, 3.4 mm; clypeal length, 0.54 mm (type 0.51 mm); scutal length, 1.31 mm.

Head. Yellow areas: (1) paraocular area, except lowermost corner, below a line originating about midlevel of antennal socket and extending diagonally upward to a point on the orbit slightly below or slightly above level of upper rim of antennal socket and below lower margin of facial fovea (to almost all black); area below level of middle portion of frontoclypeal suture tumid; (2) clypeus with narrow, longitudinal stripe medially (to all black, rarely); (4) supraclypeal area in a semilunar shape (absent, rarely); (5) absent on subantennal plate (to completely yellow). (8) Hair of vertex mixed colorless and brown, of frons fulvous, both longer than long hairs of scutum; of clypeus black. (10) Punctures along ocellocular line 2-3 pwa with smooth interspaces; impunctate area laterally adjacent to posterior ocellus finely roughened; punctures of frons adjacent to upper portion of frontal line deep, distinct, less than 1 pwa, interspaces brassy, faintly roughened (30×). (12) Clypeus with punctures of disc approximately equal in size to the average frontal puncture, deep, 3-4 pwa, interspaces finely roughened (to barely discernibly roughened in part) (30×). (13) Orbital convergence ratio as 1.31:1.21, 1.08 (type 1.33:1.26, 1.05). Facial fovea with indistinct mesal border, broader medially, narrowed above and below. (14) Galea shiny despite minute pebbling; length intermediate between antennocellar and clypeocellar; galeal gap exceeds length of galea exposed beyond closed mandibles. (15) Head width/head length 2.16: 1.75, 1.23 (type 2.21:1.84, 1.20). (17) Eye length, mio, and flagellar length as 1.28:1.21:1.26 (type 1.28:1.26:N.A.). (18) Interocellar, ocellocular, antennocular, and interantennal as 0.31:0.39:0.31:0.32 (type 0.29:0.39:0.32:0.31). (19) Ocellolabral greater than clypeal width 1.45:1.36, 1.07. (20) Clypeocellar to outer subantennal sutural as 0.90:0.71, 1.27 (type 0.90: N.A.). (21) Basal labial palpomere 3.6 (type 3.0) times length of others combined, 40:11 (type 36:12). (22) Flagellar length about 2.3 times length of scape, 1.26:0.54 (type 1.29:0.57).

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 2.5 times mow. (24) Scutal and scutellar hairs of two kinds, longer ones brown (to fulvous). Hair of metanotum fulvous. (25) Scutal disc with punctures fine, about 2 pwa, interspaces shiny, becoming exceedingly fine and crowded to less than 1 pwa anteriad, interspaces finely roughened and faintly (to strongly) brassy colored. (26) Dorsal enclosure of propodeum relatively dull with fine, irregularly longitudinal ridges, median portion not distinctly bordered posteriorly, length not much exceeding length of lateral area. (27) Legs with light color the same as on face. (28) Spur with about 25 fine, short teeth; spur length half length of middle basitarsus, 0.51: 0.80 (type 0.51:0.75). (30)Tegula dark brown. Humeral plate dark brown.

(32) Marginal cell 6-9 subequal to and 3-4 less than 9-wt, 1:00:0.80:1.04 (type 1.05:N.A.:1.02).

Metasoma. (35) Tergum 1 with punctures of median area extremely fine, about 2 pwa, interspaces shiny (or with a silken sheen). Declivity of tergum 1 with a fine, silken sheen.

MALE. Length, 6.0 mm (type 6.2 mm); forewing length, 5.0 mm (type 4.6 mm); hindwing length, 2.86 mm; clypeal length, 0.44 mm (type 0.53 mm); scutal length, 0.95 mm.

Head. Yellow areas: (1) paraocular area below an ascending diagonal line from upper outer edge of antennal rim tangent to (or indented by) lower end of facial fovea, ending on orbit slightly above level of end of facial fovea; (2) clypeus; (4) supraclypeal area extending well above level of upper antennal rims (0.2-0.5 mow); (5) subantennal plate and adjacent antennal rim; (6) mandible, basal two-thirds; (7) scape (sometimes with small, brown, trianguliform area on inner upper corner). (8) Hair of vertex, frons, and clypeus fulvous (clypeus sometimes with a few apically light brown hairs to many completely light brown hairs), of gena white. (10) Punctures along ocellocular line minute, about 3 pwa (to 1 pwa), interspaces shiny; impunctate area adjacent to lateral border of posterior ocellus finely roughened; lower, dark portion of frons heavily roughened. (11) Frontal line with lower, yellow, carinate portion ending at midlevel of antennal sockets. (12) Clypeus strongly protuberant with medial portion between clear clypeal dots raised somewhat conically (sometimes raised as an indistinct, short longitudinal ridge). (13) Orbital convergence ratio 1.12:0.87, 1.29. (14) Galea dull, completely pebbled, length as in female; galeal gap subequal to length of galea exposed beyond closed mandibles. (15) Head width/head length as 1.85:1.53, 1.21 (type 2.16:N.A.). (17) Eye length, mio, and flagellar length as 1.11:0.87:1.38 (type 1.21:1.04:N.A.). (18) Interocellar, ocellocular, antennocular, and interantennal as 0.26:0.34:0.17:0.26 (type 0.29:0.39:0.24:0.24). (19) Ocellolabral greater than clypeal width, 1:22:1.14, 1.07 (type 1.43:N.A.). (20) Clypeocellar to outer subantennal sutural as 0.77:0.58, 1.33 (type 0.90:N.A.). (21) Basal labial palpomere 1.5-1.8 times length of others combined. (22) Flagellar length 3.0-3.4 times length of scape, 1.38:0.43.

Mesosoma. (23) Yellow areas: large patch between middle coxal cavities truncate anteriorly 1 mow or more posterior to front coxae; smaller area between hind coxal cavities contiguous anteriorly with mesosternal patch; medial interruption of pronotal stripe about 2 mow. (24) Scutal and scutellar long and short hairs fulvous (white in faded specimens). Scutellar hair pad dark brown, barely extending to mesal end of yellow of scutellar crest. Metanotal hair pad dark brown, mesal margins separated by about 3 mow. (25) Scutal disc with punctures fine, 1 pwa or less, interspaces finely roughened but relatively shiny (30×), becoming very fine and crowded anteriorly. (26)

Dorsal enclosure of propodeum with fine, reticulate ridges medially, and distinct, fine roughening laterally. (27) Foreleg yellow (sometimes with base of coxa brown, apicotarsus testaceous); mediotarsomeres somewhat dorsoventrally flattened, widths about 0.75 times lengths. (28) Middle leg yellow (often with base of coxa brown, femur with basal brown spot, apicotarsus testaceous); mediotarsomeres cylindrical, widths about half of length. (29) Hind leg yellow (often with variable amounts of brown on base of coxa, inner surface of trochanter, base of femur especially inner or posterior surface; posteroventral surface of basitarsus and entire apicotarsus testaceous), mediotarsi similar to front mediotarsi but larger. (30) Tegula brown with anterior yellow spot (to all brown). Humeral plate brown (to testaceous). (32) Marginal cell 6-9 greater than, and 3-4 considerably less than 9-wt, 0.80:0.66: 0.77.

Metasoma. (35) Tergum 1 with punctures of median area very minute, smaller than on scutum, 1-2 pwa, interspaces shiny.

Type Material. Holotype female of *andreniformis,* No. 17.a.1798, and holotype male of *flavipes,* No. 17.a.1799, both from East Florida and both collected by E. Doubleday in 1838, are in the British Museum (Natural History). The type of *C. lepidus,* from Georgia, collected by Morrison, is in the Acad emy of Natural Sciences of Philadelphia, Pennsylvania. The type of *vernalis* is presumably in the Provincial Museum, Quebec, Canada. The above descriptions are primarily based upon specimens from northern Georgia with comparative measurements for the female type of *andreniformis* and the male type of *flavipes.*

Distribution. This is the most widespread species in the United States. It occurs in the entire eastern United States and southeastern Canada and the Maritime Provinces. With the exception of a mating pair of specimens from the southwestern corner of Utah, all records are from east of the Rocky Mountains and its western boundary is the Rocky Mountain Front Range from Montana to Colorado, southeast to central Oklahoma, south to East Texas and the Texas Gulf coast.

It has been collected from early April to late September in the southern states, but mostly in June and July. In the northern states it has been taken from early June to early October, but mostly in July. Doubtless, further collecting will find it with an extreme as late in the southern states as in the northern ones.

The highest altitude at which it is recorded is about 5700 feet at the foot of the Front Range of the Rocky Mountains at Boulder, Colorado.

Ecologically, it occurs in bare, clayey soil (loam, clay loam, silt loam) where small-flowered leguminous plants, especially of the clover group, thrive during its active season. It is likely to be found on almost any school campus,

playground, or sports field within its range. For this reason I suggest the common name, the Campus Bee.

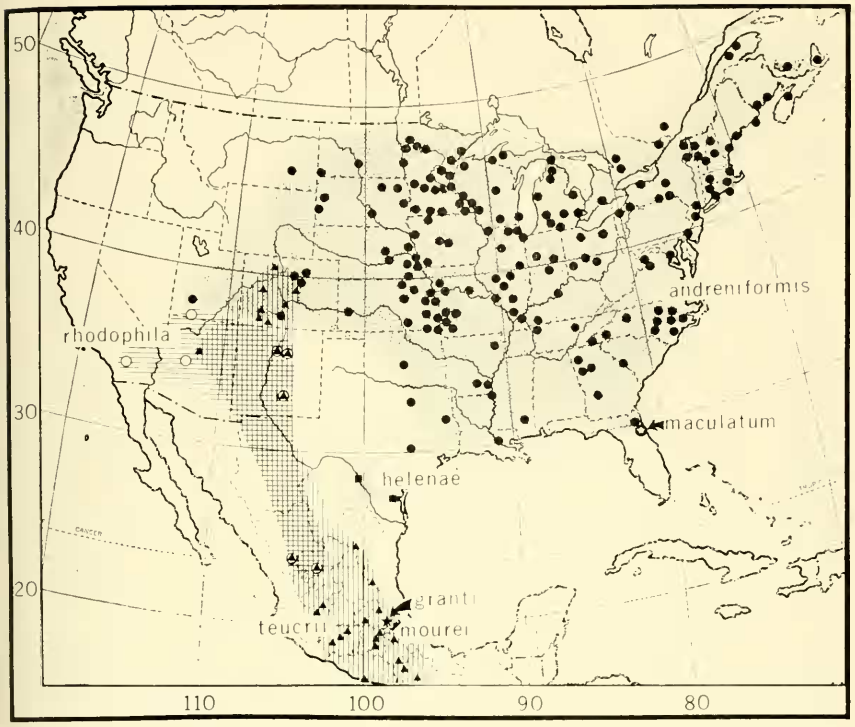
I have not examined the type material in the British Museum but I have examined the type of *C. lepidus* as well as Prof. T. B. Mitchell's homotypes of *andreniformis* and *flavipes*. In addition, I have examined approximately 5,000 specimens from the localities shown in Map 1.

The following western localities seem worth indicating in detail: COLORADO: Alamosa; Boulder; Golden, South Table Mountain; Longmont; White Rocks, near Valmont. MONTANA: Forsyth. UTAH: Parowan Canyon. The other localities are cited in a thesis on deposit in the library of The University of Kansas.

GEOGRAPHIC VARIATION. The most striking variation in the males is in the coloration of middle and hind trochanters and femora. Males from east of the Mississippi exhibit a higher incidence and greater amount of dark color on these parts. The amount of yellow increases to a maximum with a specimen from near Parowan, Utah. The most obviously variable feature in the females is the amount of yellow on the face. It parallels the situation in the male legs. No males exhibit all brown middle or hind femora, and no females exhibit all black faces. Some females from North Carolina and Vermont, however, have the yellow reduced to a mere spot on the paraocular area and a line or dot on the disc of the clypeus. Clypeal hairs of both male and female show a similar trend although they are subject to considerable fading after preservation.

BIONOMICS. This is fully discussed in the section on biology and ecology of *C. andreniformis*.

FLOWER RECORDS. *Achillea, Ailanthus altissima, Ammania coccinea, Amorpha canescens, Anaphalis margaritacea, Asclepias, Aster ericoides villosus, Bidens aristosa, Boltonia asteroides, Brassica, Castanea pumila, Ceanothus americanus, Chrysanthemum leucanthemum, Chrysopsis, Cleome, Convolvulus arvensis, C. sepium, Coreopsis palmata, C. tripteris, Cryptotaenia canadensis, Cucumis, Desmodium marilandicum, D. paniculatum, Dianthera americana, Epilobium, Erigeron, Eryngium yuccifolium, Gerardia tenuifolia, Geum album, Gillenia stipulacea, Hedeoma pulegioides, Hedyotis nigricans, H. purpurea, Helenium, Hypericum perforatum, Lindernia dubia riparia* (Raf.) (=*Ilsyanthes riparia*), *Lespedeza capitata, L. procumbens, L. repens, L. reticulata, Ligustrum, Lippia lanceolata, Lycopus sinuatus, Lythrum alatum, Medicago sativa, Malva neglecta, M. rotundifolia, Melilotus alba, M. officinalis, Nepeta cataria, Oenothera laciniata, Oxalis dillenii, O. stricta, Penstemon, Petalostemon candidum, Polygala sanguinea, Polygonum buxiforme, P. convolvulus, P. pennsylvanicum, Portulaca, Potentilla monspeliensis, P. recta, Prunella vulgaris, Prunus, Psoralea onobrychis, P. tenuiflora, P. tenuiflora floribunda, Pycnanthemum flexuosum, P. pilosum, P. virginianum, P. lanceolatum, Raphanus sativus, Rhus glabra, Rosa* (wild), *Rubus, Rudbeckia triloba, Serinea oppositifolia, Sisymbrium repardum, Solanum carolinense, Solidago canadensis, Spiranthes gracilis, Stachys palustris, Stellaria,*



Map 1. Map showing the known distributions of *Calliopsis (Calliopsis) andreniformis* Smith, *C. (C.) rhodophila* Cockerell, *C. (C.) helenae* Shinn, *C. (C.) teucrii* Cockerell, *C. (C.) mourei* Shinn, and *C. (C.) granti* Shinn. The presumptive collection locality for *Acamptopoeum maculatum* (Smith) is also shown.

Strophostyles pauciflora, Stylosanthes biflora, Symphoricarpos, Tamarisk, Trifolium hybridum, T. pratense, T. repens, Verbena bracteata, V. bracteosa, V. hastata, V. stricta, V. urticifolia, Verbesina helianthoides, Veronica spicata, Vicia.

CALLIOPSIS (CALLIOPSIS) TEUCRII Cockerell

(Figs. 14-17; Map 1)

Calliopsis teucrii Cockerell, 1899, *in* Cockerell and Porter, Ann. Mag. Nat. Hist. (7) 4:412, female; Cockerell, 1906, Trans. Amer. Ent. Soc., 32:299; Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric., Monogr. No. 2:1103.

Calliopsis lepida var. α Cockerell, 1901, Ann. Mag. Nat. Hist., (7) 7:128, male, female.

Calliopsis lepida Cockerell, 1906 (not Cresson, 1878), Trans. Amer. Ent. Soc., 32:299. (misidentification)

Calliopsis sp., Wille, 1956, Univ. Kansas Sci. Bull., 38:453, 474-475, female (thoracic musculature).

Closest to *andreniformis,* the females of which are virtually identical with *teucrii,* and are best separated by the key characters. The male of *teucrii* has a brown scape, but that of *andreniformis* is yellow.

Female. Length, 6.7 mm; forewing length, 4.6 mm; hindwing length, 3.2 mm, clypeal length, 0.46 mm, scutal length, 1.02 mm.

Head. Yellow areas: (1) paraocular area with a small patch bordering orbit below midlevel of antennal socket (to yellow, except lowermost corner, below a line originating at middle of, or slightly above, outer subantennal suture and extending diagonally upward ending on orbit at or below midlevel of antennal socket, well below lower rim of facial fovea, and lower than *andreniformis* in most cases); (2) absent on clypeus (to broad longitudinal median stripe from frontoclypeal suture to about 0.5 mow above preapical groove); (4) supraclypeal area with 2 minute dots (to full semilunar area reaching to slightly below midlevel of antennal socket); (5) absent on subantennal plate (to completely yellow). (8) Hair of type faded. Hair of fresh specimens: on vertex mixed brown and fulvous, on frons fulvous, on clypeus blacker, coarser, thicker than in *andreniformis*. (10) Punctures along ocellocular line 2-3 pwa, interspaces smooth; impunctate area adjacent to lateral border of posterior ocellus almost imperceptibly roughened (30×) and quite shiny; punctures of frons adjacent to upper portion of frontal line as in *andreniformis* except larger and more distinctly roughened (30×). (11) Frontal line with lower portion as in *andreniformis* except more distinct. (12) Clypeus with punctures of disc larger than frontal punctures, deep, 2-3 pwa, interspaces shinier than in *andreniformis* with extremely fine roughening. (13) Orbital convergence ratio as 1.19:1.11, 1.08. Facial fovea with distinct mesal border, linear but slightly wider below, narrower than in *andreniformis*. (14) Galea somewhat shiny but finely pebbled; length as in *andreniformis* (except in Flagstaff, Arizona, specimens where length exceeds clypeocellar 1.19:0.94); galeal gap to length of galea exposed beyond closed mandibles, variable. (15) Head width to head length as 1.96:1.55, 1.26 (1.20-1.28). (17) Eye length, mio, and flagellar length as 1.11:1.11:1.21(1.24:1.19:1.29). (18) Interocellar, ocellocular, antennocular, and interantennal as 0.29:0.36:0.28:0.28 (0.31:0.39:0.31:0.31). (19) Ocellolabral greater than clypeal width, 1.29:1.19, 1.08. (20) Clypeocellar to outer subantennal sutural as 0.83:0.63,1.32. (21) Basal labial palpomere about 4.0(3.9-4.8) times length of others combined. (22) Flagellar length about 2.4 times length of scape, 1.21:0.49.

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 2 mow. (24) As in *andreniformis* except long scutal and scutellar hairs always brown. (25) Scutal disc with punctures slightly larger than in *andreniformis,* 1 pwa, interspaces shiny, becoming finer and crowded anteriorly, but less so than in *andreniformis,* less than 1 pwa, no discernible roughening (30×) (to very slight), faintly to strongly greenish metallic colored. (26) Dorsal enclosure of propodeum relatively dull, with finer, more regularly longitudinal ridges than in *andreniformis;* median portion more distinctly bordered posteriorly, and proportionately longer in relation to lateral

areas than in *andreniformis*. (27) Legs with light color the same as on face. Foreleg with yellow like that of *andreniformis*. (28) Middle leg and spur as in *andreniformis* except spur length about 0.6 (to 0.7) of length of middle basitarsus, 0.47:0.73. (30) Tegula brown. (32) Marginal cell 6-9 longer than, and 3-4 shorter than 9-wt, 0.99:0.83:0.94.

Metasoma. (34) Tergal hair bands white. Bands of terga 1-2 as in *andreniformis*. (35) Tergum 1 with punctures of median area fine, mostly 1 pwa, interspaces highly polished. Declivity of tergum 1 with a high polish.

Male. Length, 5.5 mm; forewing length, 4.3 mm; hindwing length, 3.13 mm; clypeal length, 0.48 mm; scutal length, 0.78 mm.

Head. Yellow areas: (1) paraocular area as in *andreniformis* but more horizontally truncate above; (2) clypeus as in *andreniformis* except apical border black; (4) supraclypeal area as in *andreniformis* except height of area lowered with decreasing latitude, upper limit of area below middle of antennal socket near southern limit of range; (5) subantennal plate as in *andreniformis*. (7) Scape and pedicel brown. (8) Hair on vertex and frons fulvous, on clypeus brown (to black), on gena white. (10) As in *andreniformis* except impunctate area usually very shiny despite minute roughening, and punctures of lower, dark portion of frons larger than in *andreniformis*. (11) Frontal line with lower, carinate portion ending slightly above midlevel of antennal socket. (12) Clypeus as in *andreniformis*. (13) Orbital convergence ratio as 1.09:0.85,1.28. (14) Galea dull, completely pebbled, somewhat ligulate in repose; galeal gap subequal to (to less than) length of galea exposed beyond closed mandibles. (15) Head width to head length as 1.77:1.56,1.13. (17) Eye length, mio, and flagellar length as 1.02:0.85:1.53. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.27:0.34:0.17:0.26, close to *andreniformis*. (19) Ocellolabral greater than clypeal width, 1.24:1.11,1.12. (20) Clypeocellar to outer subantennal sutural as 0.77:0.61,1.25. (21) Basal labial palpomere 1.4-2.0 times length of others combined. (22) Flagellar length about 3.6 times length of scape, 1.53:0.43.

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 1.5 mow. (24) Scutal and scutellar hair of two kinds, one short, fulvous, the other long, brown. Metanotal hair fulvous (to dirty white). Scutellar and metanotal hair pads as in *andreniformis* except metanotal hair pads much closer, 1.5 mow between mesal margins. (25) Scutal disc with punctures larger than *andreniformis*, 1 pwa or less, interspaces smooth (to finely roughened), becoming crowded anteriad. (26) Dorsal enclosure of propodeum with larger, thicker, reticulate ridges medially, with shorter longitudinal ridges laterally partly hidden by metanotal hair pad. Median portion of enclosure distinctly larger and longer than in *andreniformis*. (27) Legs with light color the same as on face. Foreleg with yellow on coxal apex,

ventral trochanteral surface, basal half, more or less, of femur, tibia entirely except for posterior brown patch, tarsus entirely; mediotarsus as in *andreniformis*. (28) Middle leg colored like foreleg except apicotarsus testaceous; mediotarsomeres as in *andreniformis*. (29) Hind leg colored like middle leg except yellow greatly reduced on trochanter, and brown patch present on posterior tibial surface; apicotarsus testaceous; mediotarsomeres as in *andreniformis*. (30) Tegula brown. (31) Wing tip more distinctly brown apically beyond cells than in *andreniformis*. (32) Marginal cell 6-9 greater than, and 3-4 subequal to 9-wt, 0.97:0.85:0.85.

Metasoma. (34) Tergal hair bands white. Bands of terga 1-2 more broadly interrupted than in *andreniformis*. (35) As in *andreniformis*. (37) Sterna brown.

Type Material. Holotype female from Las Vegas, New Mexico, July 11 (T. D. A. Cockerell), on *Teucrium laciniatum,* is at the University of California, Riverside, California. It has the yellow markings of the face greatly reduced compared to usual specimens, and is smaller than the average as well.

The above description of the male is based primarily on a specimen from Coaldale, Colorado, 7800 ft., Aug. 4, 1957 (C. D. Michener).

Distribution. Colorado to Oaxaca. The species is widespread in central México but no specimens bridge the gap from Fresnillo, Zacatecas to San Jose, New Mexico. This seems likely to be a collecting bias rather than a real gap in distribution.

Seasonal distribution is June to Aug. 31 with one late record of Sept. 24, 1938, at Agua Fría, Hidalgo (L. J. Lipovsky).

The numerous records of the bee at altitudes of 5,000 to 8,000 ft. may indicate it is a mountain form that may, indeed, be absent from the desert parts of Durango and Chihuahua.

In addition to the type material approximately 305 specimens have been studied from the following localities: Arizona: Flagstaff (4 mi. N.; 6 mi. W.). Colorado: Animas, 6600 ft.; Coaldale, 7800 ft., Fremont Co.; Eleven-Mile Canyon, 8000 ft., Park Co.; Estes Park; Florissant; Ouray, 8500 ft.; Pagosa Springs, 7500 ft.; Ridgway, 7000 ft. New Mexico: Las Vegas; Ruidoso; Santa Fe; San Jose; Sapello. Distrito Federal: Contreras. Durango: Nombre de Dios, 5900 ft. Guerrero: Acapulco. Hidalgo: Agua Fría; Epazoyucan; Jacala (21 mi. S.W.; 7, 24 mi. N.E.), 5000 ft.; Lagunilla; Pachuca (14 mi. S.W.), 7500 ft.; Tepeapulco (3 mi. N.); Tizayuca (13.5 mi N.E.), 7700 ft. Jalisco: San Juan de los Lagos; Tepatitlán. Mexico: Chapingo; Tepexpán, 6900 ft. Michoacan: Morelia (22 mi. W.), 6800 ft.; Pátzcuaro; Tzitzio (3 mi. N.), 5500 ft. Morelos: Cuernavaca. Nuevo Leon: El Cercado (4 mi. W.). Oaxaca: Oaxaca (14 mi. E.), 5000 ft.; Tamazulapan (2 mi. N.W.), 6000 ft. Puebla: Chila (5 mi. S.), 5700 ft.; Huachinango (4 mi. S.W.), 5700 ft.; Teziutlán (5 mi. N.E.), 5100 ft. Queretaro: San Juan del Rio (10 mi. E.), 6500 ft. San Luis Potosi: Ciudad del Maíz (5 mi. E., 4700 ft.; 20 mi. N.E., 3000 feet). Tlaxcala: Apizaco (8 mi. W.; 8 mi. W.N.W.), 8200 ft. Zacatecas: Fresnillo (9 mi. S.).

Flower Records. *Asclepias, Convolvulus incanus, Heterotheca chrysopsidis, Melilotus officinalis, Oxalis, Potentilla, Stylosanthes, Taraxacum, Teucrium laciniatum.*

CALLIOPSIS (CALLIOPSIS) GRANTI, new species

(Figs. 18-21; Map 1)

The species is named in honor of the late Dr. Harold J. Grant, Jr., my long time friend and companion in the field. The species is intermediate between *teucrii* and *rhodophila,* but is closer to the latter. It is easily separated from both species by the key characters.

Male. Length, 5.2 mm; forewing length, 4.2 mm; hindwing length, 3.02 mm; clypeal length, 0.39 mm; scutal length, 0.80 mm. Integument of head, mesosoma, and first metasomal tergum with faint brassy, metallic tints.

Head. Yellow areas: (1) paraocular area as described for subgenus, upper boundary somewhat convex dorsally; (2) clypeus, dots black; border of lateral portion of apex black; frontoclypeal suture black. (4) Supraclypeal area, summit below midlevel of antennal socket; (5) subantennal plate, except lowermost outer corner triangularly black; (6) mandible with anterior and posterior borders black. (7) Scape, pedicel, flagellomeres 1 and 2, black. (8) Hair of vertex and frons fulvous, of clypeus black. (10) Punctures of upper frons larger than in *teucrii,* interspaces shiny. (11) Frontal line with lower portion a low, finely sulcate, carina. (13) Orbital convergence ratio as 1.05: 0.83,1.26. (14) Galea strongly pebbled, but little shiny, shinier than *teucrii,* with rounded, blunt tip; galeal gap estimated to be shorter than length of galea exposed beyond closed mandibles, 0.36:0.37. (15) Head width to head length as 1.67:1.43,1.17. (17) Eye length, mio, and flagellar length as 0.95: 0.83:1.19. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.27:0.32:0.17:0.27. (19) Ocellolabral equal to clypeal width, 1.12:1.12,1.00. (20) Clypeocellar to outer subantennal sutural as 0.73:0.54,1.34. (21) Basal labial palpomere 1.4 times length of others combined. (22) Flagellar length about 3.2 times length of scape, 1.19:0.37.

Mesosoma. (23) Light areas yellow. (24) Scutal and scutellar hairs short, white and long, brown. Scutellar hair pads black, separated by 0.37 mm, slightly more than 2 mow, somewhat farther than in *rhodophila.* Metanotal hair pads black, subquadrate, contiguous posteriorly, separated anteriorly leaving a triangular area from which arises a tuft of long white hairs. (25) Scutal disc with punctures slightly larger than in *teucrii,* much larger than in *rhodophila,* 1 pwa or less, interspaces shiny. (26) Dorsal enclosure of propodeum covered by metanotal hair pad except for small median area which is abruptly elevated. (27) Legs with light color the same as on face. Foreleg yellow except dark brown on basal half of coxa, dorsal half of trochanter; anterior half, passing dorsally to posterior three-fourths, of femur, and most of posteroventral surface of tibia; mediotarsus testaceous, distitarsus brown. (28) Middle leg colored like foreleg. (29) Hind leg colored like middle leg except brown patch on posterior surface of tibia reduced and located medially.

(30) Tegula brown. (32) Marginal cell 6-9 greater than, and 3-4 subequal to 9-wt, 0.94:0.80:0.82.

Metasoma. (34) Tergal hair bands very sparse on all terga. Band of tergum 1 represented by only a small lateral group of sparse hairs. (35) Tergum 1 with punctures of median area scarce, larger than on scutum, irregularly distributed, of area immediately laterad larger than on scutum, about 1 pwa, interspaces highly polished; punctures shallow, some eccentric, giving pock-marked appearance suggesting deformity but bilaterally symmetrical. Declivity of tergum 1 finely lineolate, very shiny.

TYPE MATERIAL. Holotype male from Apizaco (8 miles W.N.W.), Tlaxcala, 8200 feet, June 18, 1961 (University of Kansas Mexican Expedition), on *Stylosanthes,* is in the Snow Entomological Museum of The University of Kansas, Lawrence.

CALLIOPSIS (CALLIOPSIS) RHODOPHILA Cockerell

(Figs. 22-25; Map 1)

Calliopsis andreniformis rhodophila Cockerell, 1897, Proc. Acad. Nat. Sci. Philadelphia, 49:350, male, not female; *idem,* Bull. Univ. New Mexico, 24:19; *idem,* 1898, Trans. Amer. Ent. Soc. 25:196.

Calliopsis rhodophila; Cockerell, 1898, Bull. Denison Univ., 11:52: Birkman, 1899, Ent. News, 10:244 (rec., Fedor, Lee Co., Texas, det. Friese); Cockerell, 1902, Amer. Naturalist, 36:810; *idem,* 1906, Trans. Amer. Ent. Soc., 32:299; *idem,* Bull Amer. Mus. Nat. Hist., 22:440; *idem,* 1921, Amer. Mus. Novitates, 24:14; *idem,* 1922, 40:4; Timberlake, 1947, Pan-Pac. Ent., 23:29; Michener, 1951, *in* Muesebeck *et al.,* U.S. Dept. Agric., Monogr. No. 2:1103.

Closest to *teucrii* and *granti* but fairly easily separated from them by the long, sharply pointed galeae which are slim and tapering towards their apices, and the galeae appear to be somewhat converging towards each other. The few specimens of this bee I have examined have come from widely separated geographic areas, and the species appears to be rare.

FEMALE. Length, 6.8 mm; forewing length, 4.8 mm; hindwing length, 3.43 mm; clypeal length, 0.51 mm; scutal length, 1.12 mm.

Head. Yellow areas: (1) paraocular area, except lowermost corner, below a sinuous line originating at middle of, or slightly above outer subantennal suture and extending upward ending on orbit at or above midlevel of antennal socket, usually not touching lower border of facial fovea, but if touching lower border of fovea then ending on orbit above lower border of fovea, usually below upper rim of antennal socket; (2) clypeus, a median, longitudinal stripe about as wide as width of yellow supraclypeal area, upper portion somewhat constricted just below base; lower margin about 0.5 mow above clypeal apex; (4) supraclypeal area broadly semilunar to broadly pentagonal, extending to midlevel, or above, of antennal socket; (5) usually absent on subantennal plate, but sometimes on lower half. (8) Hair like *andreniformis,* except clypeal hairs finer. (10) Punctures along ocellocular line

sparse, very fine, with shiny interspaces, impunctate area adjacent to lateral border of posterior ocellus shiny (30×); punctures of frons adjacent to upper portion of frontal line deep, distinct, 1-2 pwa, interspaces smooth, moderately shiny (30×). (12) Clypeus with punctures of disc larger than frontal punctures, deep 2-3 pwa, interspaces shiny, highly polished, except faintly roughened beside subantennal plate. (13) Orbital convergence ratio as 1.28:1.17, 1.09. Facial fovea linear, distinctly bordered medially. (14) Galea smooth, shiny; apex pointed (30×) in contrast to varying degrees of broadness in other species of *Calliopsis s.s.;* length only slightly less than antennocellar; galeal gap less than length of galea exposed beyond closed mandibles. (15) Head width to head length as 2.11:1.58,1.33. (17) Eye length, mio, and flagellar length as 1.19:1.19:1.22. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.34:0.34:0.29:0.32. (19) Ocellolabral subequal to clypeal width, 1.34:1.36. (20) Clypeocellar to outer subantennal sutural as 0.83:0.70, 1.19. (21) Basal labial palpomere about 2.0 times length of others combined; ventral hairs fine, straight. (22) Flagellar length about 2.3 times length of scape, 1.22:0.54.

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 2 mow. (24) As in *andreniformis.* (25) Scutal disc with punctures fine, deep, distinct, about 3 pwa, interspaces shiny, becoming crowded anteriorly to 1 pwa with shiny interspaces. (26) Dorsal enclosure of propodeum shiny, with obliquely longitudinal ridges laterally, straight medially; posterior border carinate, a small medial portion of border raised distinctly upward; median portion longer than lateral portion. (27) Foreleg without (or with) yellow spot on extreme apex of femur. (28) Middle leg colored like foreleg; spur length about 0.6 length of middle basitarsus, 0.49:0.82. (30) Tegula brown. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 1.07:0.88:1.02.

Metasoma. (34) Tergal hair bands white. (35) Tergum 1 with punctures of median area exceedingly fine, 2-3 pwa anteriorly to impunctate posteriorly, interspaces highly polished.

Male. Length, 5.9 mm; forewing length, 4.3 mm; hindwing length, 3.10 mm; clypeal length, 0.46 mm, scutal length, 0.75 mm.

Head. Yellow areas: (1) paraocular area as in *teucrii;* (2) clypeus, dots pale brown; lateral border of apex black; frontoclypeal suture black; (4) supraclypeal area, summit between midlevel and upper border of antennal socket; (5) subantennal plate; (6) mandible with anterior and posterior borders black. (7) Scape and pedicel black; flagellomeres 1-2 partly black. (8) Hair on vertex and frons white, on clypeus black. (10) Punctures of upper frons largest of the *andreniformis* group, contiguous, shallow, indistinct, interspaces dulled by fine roughening. (11) Frontal line with lower portion a high, sharp, non-sulcate carina, distinctly higher than other species

of subgenus. (13) Orbital convergence ratio as 1.17:0.88,1.33. (14) Galea highly polished, smooth, rather slim, galeal gap slightly more than half (to a third) of length of galea exposed beyond closed mandibles. (15) Head width to head length as (1.77:1.51,1.17). (17) Eye length, mio, and flagellar length as 1.09:0.88:1.48. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.31:0.32:0.19:0.27. (19) Ocellolabral subequal to clypeal width (1.21: 1.19), 1.02. (20) Clypeocellar to outer subantennal sutural as 0.78:0.58,1.35. (21) Basal labial palpomere 1.3 times length of others combined. (22) Flagellar length about 3.5 times length of scape, 1.48:0.43.

Mesosoma. (23) Light areas yellow. (24) Scutal and scutellar short hairs white, long hairs white (sometimes a few fulvous to brown on scutum posteriorly, and on scutellum). Scutellar hair pads black, apart by 0.31 mm, about 2 mow, somewhat closer than in *granti*. Metanotal hair pads as in *granti* except triangular area with apex more acute, pads larger, more extensive. (25) Scutal disc with punctures finer than in *teucrii,* mostly 2 pwa, interspaces shiny, smooth (sometimes faintly roughened). (26) Dorsal enclosure of propodeum as in *granti*. (27) Legs with light color the same as on face. Foreleg colored as in *granti*. (28) Middle leg like *granti*. (29) Hind leg colored like *granti,* except tibial patch black, located medially (or apically). (32) Marginal cell 6-9 greater than, and 3-4 subequal to 9-wt, 0.94:0.83:0.85.

Metasoma. (34) Tergal hair pads as in *granti*. (35) Tergum 1 with punctures of median area regularly distributed, finer than on scutum, extremely fine, about equal in size to those in *andreniformis,* but much more distinct, further apart at 3 pwa, interspaces highly polished. Declivity of tergum 1 highly polished.

Type Material. Holotype male from Santa Fe, New Mexico, July (T. D. A. Cockerell, Cockerell No. 3844), on *Sphaeralcea,* is in the U.S. National Museum, U. S. N. M. Type No. 3701. The female allotype, same label data except Cockerell No. 3842, U. S. N. M. Type No. 3702, is actually *teucrii*.

The above description of the female is based primarily on a specimen from Santa Fe, New Mexico, July (T. D. A. Cockerell, Ckll. No. 3843), on *Sphaeralcea!*

Distribution. The southwestern United States south to slightly north of central Mexico. Seasonal occurrence is from May to August. The highest altitudinal collection record is 5900 ft., and other records suggest a bee adaptable to low mountains.

In addition to the type material, 7 males and 18 females have been studied from the following localities: Arizona: Chino Valley. California: Kelso (7 mi. S.), Providence Mts., San Bernardino Co.; Mt. Laguna, San Diego Co.; Piñon Flat, San Jacinto Mountains, Riverside Co. New Mexico: Las Vegas; Ruidoso, Lincoln Co.; Santa Fe. Utah: Orderville, Kane Co. Durango: Nombre de Dios, 5900 ft. Zacatecas: Fresnillo (9 mi. S.E.; 1.5, 5, and 9 mi. S.).

Discussion. Too few specimens are available for positive conclusions, but the Arizona specimen, a female, is considerably duller than the others. The

galeal gap in males is proportionately greater in specimens from New Mexico (half of length of galea exposed beyond closed mandibles) than in those from Utah, California, and Mexico (a third of length of galea exposed beyond closed mandibles). Males from New Mexico are shorter than those from other states. The hair pads show very little variation.

Flower Records. *C. rhodophila* has been collected on *Sphaeralcea* in California in May, in New Mexico in July, Aug., Sept., and in Zacatecas in Aug. One record for *Solidago* is from Zacatecas in Aug.

CALLIOPSIS (CALLIOPSIS) MOUREI, new species

(Figs. 26-29; Map 1)

I take great pleasure in naming this distinctive species in honor of Padre Jesus S. Moure, C. M. F., of the University of Paraná, Curitiba, Brazil, who gave me a solid foundation for understanding the panurgine bees of South America most closely related to *Calliopsis*.

This species may be closest to *rhodophila*, but is easily distinguished from all other species of *Calliopsis s.s.* by the white facial color in combination with the cobalt blue color of the head and mesosoma.

Male. Length, 5.2 mm; forewing length, 4.1 mm; hindwing length, 3.01 mm; clypeal length, 0.44 mm; scutal length, 0.87 mm. Integumental background color of head and mesosoma metallic cobalt blue, of metasoma metallic greenish.

Head. White areas: (1) paraocular area as described for subgenus, upper boundary dorsally convex; (2) clypeus, dots testaceous; border of lateral portion of apex black; frontoclypeal suture light; (4) supraclypeal area, summit 0.5 mow above upper edge of antennal socket; (5) subantennal plate; (6) mandible with anterior and posterior border black. (7) Scape, pedicel, and flagellomere 1 black; flagellomere 2 partly black. (8) Hair on vertex, frons, clypeus, and gena white. (10) Punctures of upper frons fine, 2-3 pwa, interspaces shiny, cobalt blue, minutely roughened (30×). (11) Frontal line with lower portion a medium-height, non-sulcate carina. (13) Orbital convergence ratio as 1.11:0.82,1.35. (14) Galea finely pebbled, dull, width somewhat slim as in *rhodophila*, tip very narrowly rounded, intermediate between *rhodophila* and *granti;* galeal gap slightly shorter than length of galea exposed beyond closed mandibles, 0.36:0.37. (15) Head width to head length as 1.73:1.50,1.16. (17) Eye length, mio, and flagellar length as 1.02:0.82:1.39. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.32:0.31:0.17:0.26. (19) Ocellolabral greater than clypeal width, 1.22:1.11,1.11. (20) Clypeocellar to outer subantennal sutural as 0.78:0.56,1.39. (21) Basal labial palpomere 1.8 times length of others combined. (22) Flagellar length about 3.6 times length of scape, 1.39:0.39.

Mesosoma. (23) Light colored areas: of pronotal stripe, pronotal lobe, meso- and metasternum, white; of scutellar crest, yellow. (24) Scutal and scutellar hair white. Scutellar hair pads black, widely separated, confined to lateral scutellar areas, separated by 0.49 mm. Metanotal hair pads black, large, broadly oval, separated by 0.14 mm, less than 1 mow. (25) Scutal disc with punctures finer than in *rhodophila,* distinct, mostly 2 pwa, interspaces shiny, smooth. (26) Dorsal enclosure of propodeum with median portion exposed, lateral portion only covered anteriorly by metanotal hair pad; seven slightly irregularly longitudinal ridges on median portion, interspaces shiny; less distinct, lower ridges on lateral portion, interspaces shiny posteriorly, roughened anteriorly. (27) Legs with light color the same as on face except yellow on front and middle coxae. Foreleg colored as in *granti* except dark tibial patch much smaller. (28) Middle leg colored as in *granti* except dark tibial patch much smaller. (29) Hind leg colored as in *granti* except dark tibial patch much smaller. (32) Marginal cell 6-9 greater than, and 3-4 slightly less than 9-wt 0.87:0.75:0.80.

Metasoma. (34) Tergal hair bands as in *granti.* (35) Tergum 1 with punctures of median area regularly distributed, finer than on scutum, slightly larger than in *rhodophila,* 2-3 pwa, interspaces smooth shiny. Declivity of tergum 1 roughened, somewhat shiny.

TYPE MATERIAL. Holotype male from Tepexpán, state of México, Aug. 12, 1954 (University of Kansas Mexican Expedition), is in the Snow Entomological Museum of The University of Kansas, Lawrence.

DISCUSSION. This striking species is the only one of the genus to display a metallic cobalt blue integument. Nothing is known of its biology.

CALLIOPSIS (CALLIOPSIS) HONDURASICA Cockerell

(Figs. 30-33; Map 2)

Calliopsis hondurasica Cockerell, 1949, Proc. U.S. Nat. Mus., 98 (3233): 437; Michener, 1951, *in* Muesebeck et al., U.S. Dept. Agric., Monogr. No. 2:1103; Michener, 1954, Bull. Amer. Mus. Nat. Hist., 104(1):36-38.
Calliopsis andreniformis; Cockerell, 1932, Bull. Brooklyn Ent. Soc., 27:11 (misidentification).

The closest relative of this species is *sonora* from which it is differentiated in the male by the small tan scutellar and metanotal hair pads, and in the female by the key characters of couplet 14. In Louisiana and Texas it may be mistaken for *andreniformis,* from which it is readily distinguished in the male by the much longer flagellum, and in the female by the distinctive fine puncturing on a finely roughened ground.

FEMALE. Length, 7mm; forewing length, 4.9 mm; hindwing length 3.45 mm; clypeal length, 0.49 mm; scutal length, 1.29 mm.

Head. Yellow areas: (1) paraocular area as in *rhodophila* but yellow not

Map 2. Map showing the known distributions of *Calliopsis (Calliopsis) empelia* Shinn, *C. (C.) sonora* Shinn, *C. (C.) zora* Shinn, and *C. (C.) hondurasica* Cockerell.

touching lower border of facial fovea; (2) as in *rhodophila;* (4) supraclypeal area, broadly semilunar, extending to below midlevel of antennal socket; (5) absent on subantennal plate (to all yellow). (8) Hair like *andreniformis,* except clypeal hairs fulvous (to brown). (10) Punctures along ocellocular line 3 pwa, very fine, with dull roughened interspaces; impunctate area laterally adjacent to posterior ocellus dull (30×); frontal punctures adjacent to upper portion of frontal line finer than in *rhodophila,* distinct, somewhat shallower, 1-2 pwa, interspaces dull, roughened (30×). (12) Clypeus with punctures of disc much larger than upper frontal ones, 2-3 pwa, interspaces roughened except shiny in median apical portion. (13) Orbital convergence ratio as 1.38: 1.31,1.05. Facial fovea shallow, broadened medially (to almost borderless in some Panamanian specimens). (14) Galea smooth, shiny; length slightly less than, to subequal to, antennocellar; galeal gap more than twice length of galea exposed beyond closed mandibles, 0.61:0.26. Some hairs of stipes bent abruptly at tip and often curled in a plane perpendicular to the shaft. (15) Head width to head length as 2.30:1.72,1.34. (17) Eye length, mio, and flagellar length as 1.24:1.31:1.41. (18) Interocellar, antennocular, and interantennal as 0.37:0.41:0.36:0.34. (19) Ocellolabral greater than clypeal width, 1.45:1.38, 1.05. (20) Clypeocellar to outer subantennal sutural as 0.94:0.75,1.25. (21)

Basal labial palpomere 1.5 times length of others combined; many ventral hairs, thickened to stout setae. (22) Flagellar length about 2.3 times length of scape, 1.41:0.61.

Mesosoma. (23) Light area yellow; medial interruption of pronotal stripe about 2.5 mow. (24) Longer scutal and scutellar hairs only slightly darker than shorter hairs. Hair of metanotum white. (25) Scutal disc with punctures very fine, deep, distinct, about 2 pwa, interspaces extremely dulled by very fine roughening. (26) Dorsal enclosure of propodeum shiny, with numerous vermiform ridges, posterior border carinate; median portion about same length as lateral portion. (27) Foreleg without yellow spot on femur. (28) Middle leg colored like foreleg; spur length about 0.6 times length of middle basitarsus. (30) Tegula brown. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 1.11:0.85:1.00.

Metasoma. (34) Tergal hair bands white. (35) Tergum 1 with punctures of median area exceedingly fine, 3 pwa, interspaces dull, finely roughened.

Male. Length, 6.0 mm; forewing length, 4.5 mm; hindwing length, 3.40 mm, clypeal length, 0.44 mm, scutal length, 1.05 mm.

Head. Yellow areas: (1) paraocular area as described for subgenus, upper boundary a relatively straight line; (2) clypeus, dots testaceous; lateral border of apex pale; frontoclypeal suture pale; (4) supraclypeal area, truncate dorsally (to somewhat emarginate) at midlevel of antennal socket; (5) subantennal plate; (7) scape, except a roughly triangular area of brown, base of triangle along apex of scape anteriorly and posteriorly, apex of triangle near middle of scape; pedicel, on lateral half; flagellomeres 1 and 3 partly brown. Scape unusually long. (8) Hair on vertex, frons, and clypeus fulvous. (10) Punctures of upper frons finest in subgenus, 2 pwa, interspaces smooth. (11) Frontal line with lower portion a relatively high (lower than in *rhodophila,* higher than in *mourei*), sharp carina. (13) Orbital convergence ratio as 1.33: 1.04,1.28. (14) Galea shiny, smooth at tip, lightly pebbled, dulled basad, slim, tip narrowly rounded; galeal gap greater than (to subequal to) length of galea exposed beyond closed mandibles, 0.46:0.26. (15) Head width to head length as 2.13:1.63,1.30. (17) Eye length, mio, and flagellar length as 1.17: 1.04:2.16. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.32:0.41:0.26:0.31. (19) Ocellolabral slightly less than clypeal width, 1.29:1.34, 0.96. (20) Clypeocellar to outer subantennal sutural as 0.85:0.70,1.22. (21) Basal labial palpomere 1.4 times length of others combined. (22) Flagellar length about 4.1 times length of scape, 2.16:0.53.

Mesosoma. (23) Light areas yellow. (24) Scutal and scutellar hair white to pale fulvous. Scutellar hair pads tan, small, confined to outer half of lateral portion of scutellum; often hidden by base of wing. Metanotal hair pads tan, oval, separated by 0.39 mm or about 2 mow. (25) Scutal disc with punctures fine, mostly 1.0-1.5 pwa, interspaces finely roughened, somewhat shiny. (26)

Dorsal enclosure of propodeum with indistinct reticulated ridges, interspaces strongly roughened, somewhat shiny. (27) Legs with light color the same as on face. Foreleg yellow except basal half of coxa dark brown, distitarsus testaceous. (28) Middle leg yellow except dorsal half of coxa dark brown, apicotarsus testaceous. (29) Hind leg yellow except base of coxa, dorsal apex of femur, and basal rim (often entire base) of basitibial plate brown, apicotarsus testaceous. (32) Marginal cell 6-9 greater than, and 3-4 slightly less than 9-wt, 1.02:0.75:0.88.

Metasoma. (34) Tergal hair bands as in *granti*. (35) Tergum 1 with punctures of median area exceedingly fine, distinct, 2-3 pwa, interspaces finely roughened, dull. (37) Sterna brown.

Type Material. The female holotype taken at Zamorano, Honduras, in December, is in the U.S. National Museum (U.S.N.M. No. 58444). Zamorano is S.S.E. of Tegucigalpa, in the mountains, at latitude 14.01° N., longitude 87.01° W. The above description of the male is principally based on a specimen from Amatitlán, Guatemala, 4000 ft., July 6, 1947 (C. and P. Vaurie).

Distribution. This is the most widespread species in the genus. It occurs from Central Panamá to northwestern Louisiana. It is remarkable that despite the huge area covered by this bee, it is instantly recognizable and varies relatively little geographically. Specimens from Chiapas are darker than others, with the male pronotal lobes almost entirely dark; they also show considerable pebbling which dulls the galea, whereas others are smooth and very shiny.

This bee is the only species of *Calliopsis* which has been collected in every month of the year, owing to its occurrence in tropical latitudes. Likely enough its activity span in any one area is little more than in its relatives: a few months. Collections in Panamá tend to confirm this opinion: they date only from November to February. Michener (1954) suggests the limitation of *hondurasica* activity by rainfall rather than temperature. *C. hondurasica* flies during the early part of the dry season when moist conditions with clear, sunny days bring numerous flowering plants into bloom.

In addition to the type, specimens have been studied from the following localities: Louisiana: Robson, U.S.D.A. Pecan Field Station. Texas: Brownsville; Cameron Co.; Giddings, Lee Co.; Hidalgo; Mission (State Park on Rio Grande nearby), Hidalgo Co.; Progreso; Richmond, Fort Bend Co.; Riogrande (5 mi. E.); San Manuel (10 mi. S.); Santa Maria; Southmost, Cameron Co.; Sweeny. Chiapas: Comitán (15 mi. N.W.); San Cristóbal de las Casas (39 mi. E.); Simojovel (4 mi. S.). Guerrero: Amula, 6000 ft.; Chilpancingo, 3700 ft.; Iguala (13 mi. N.), 3900 ft.; Taxco (19.5 mi. N.E.), 4800 ft.; Tepetlapa, 3000 ft. Michoacan: Apátzingan (4, 11 mi. E.). Morelos: Yautepec (4 mi. S.W.), 3800 ft. Nayarit: San Blas (5 mi. E.), 25 ft. Oaxaca: Oaxaca. San Luis Potosi: Ciudad del Maíz (5 mi. E.), 4700 ft.; El Naranjo (3.4 mi. N.E.), 800 ft.; El Salto, 1800 ft. Tamaulipas: El Limón; Jiménez (22 mi. S.); Padilla; Tampico. Veracruz: Córdoba; Gutiérrez Zamora (4 mi. E.), 100 ft.; Nautla; Puente Nacional (4 mi. W.), 900 ft. Yucatan: Temax. Guatemala: Amatitlán, 4000 ft.; Guatemala City, 5000 ft. Honduras: Agua Azul; Zamorano. Costa Rica: Playa del Coco. Panama: Chillibre, Panamá Province; Davíd; Old Panamá; Panamá City; Pueblo Nuevo, Panamá Province; Salanas. Canal Zone: Ancon Hill; Chiva Chiva; Corozal; Fort Clayton; Summit.

BIONOMICS. Professor Alvaro Wille of the University of Costa Rica at San Jose has kindly furnished, through Professor Charles D. Michener, fragmentary notes on nesting sites, nest density, and the form of the burrow. These are discussed in comparison with *andreniformis* in connection with biology and ecology of the latter.

FLOWER RECORDS. *Cassia, Kallostroemia hirsutissima, Lippia, Nama undulatum, Phyla strigosa, Teucrium, Trifolium repens, Verbena.*

CALLIOPSIS (CALLIOPSIS) SQUAMIFERA Timberlake

(Figs. 42-45; Map 3)

Calliopsis squamifera Timberlake, 1947, Pan-Pacific Ent., 23:28, male; Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric., Monogr. No. 2: 1103.

Timberlake considered this one of the species of *Calliopsis s.s.* and I concur, but it has characters which link it as an intermediate between *Calliopsis s.s.* and *Perissander.*

It is closest to *C. peninsularis,* which will doubtless be proven a *Calliopsis s.s.* when the male becomes known, but is readily distinguished by the mesotibial spur being bare and 0.75 times or more the length of the middle basitarsus (less than 0.60 in *peninsularis*).

FEMALE. Length, 5.0 mm; forewing length, 3.3 mm; hindwing length, 2.40 mm; clypeal length, 0.34 mm; scutal length, 0.85 mm.

Head. White areas: (1) paraocular area, except for lowermost corner, below a sinuous line originating at about middle of outer subantennal suture and extending to a point on orbit about 0.4 eye length below summit of eye; (2) clypeus with a broad, inverted T, the base bordering the supraclypeal area, the crossbar bordering the narrow, testaceous apical margin to the extent of the total width of clypeal emargination (reduced in some specimens to a narrowed, vertical part of the T); (4) supraclypeal area to about level of middle of antennal socket, dorsal margin evenly convex; (5) subantennal plate (to all black). (8) Hair on vertex fulvous, longer than long scutal hairs, on frons and clypeus fulvous. (10) Punctures of vertex and along ocellocular line with interspaces roughened (30×). Median punctures of frons deep, subconfluent, interspaces shiny (30×). (11) Frontal line with lower portion narrowly sulcate, becoming obsolete, ending in a slightly raised prominence at level of upper rim of antennal socket. (13) Orbital convergence ratio as 1.05:0.94,1.13. (14) Galea finely pebbled, hidden with mandibles closed. (15) Head width to head length as 1.73:1.22,1.42. (17) Eye length, mio, and flagellar length as 1.00:0.94:1.02. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.31:0.29:0.27:0.22. (19) Ocellolabral greater than clypeal width, 1.05:0.94, 1.13. (20) Clypeocellar to outer subantennal sutural as 0.71:0.51,1.40. (21)

Basal labial palpomere 0.8 times length of others combined. (22) Flagellar length about 2.2 times length of scape, 1.02:0.46.

Mesosoma. (23) Light areas yellowish; medial interruption of pronotal stripe about 3 mow. (24) Scutal and scutellar hair fulvous apicad, light brown basad, darker than hairs of vertex. Hair of metanotum fulvous. (25) Scutal disc with punctures finer and deeper than on vertex, 1-2 pwa, interspaces shiny (60×). (26) Dorsal enclosure of propodeum generally dull, slightly declivous, median portion with fine, close, vermiform, interrupted ridges, interspaces roughened, ridges becoming longitudinal and several ridge widths apart laterad, interspaces roughened. Proposed triangle adjacent to enclosure dull, roughened. (27) Legs with light color more yellowish than on face. Foreleg with cream (to yellow) on dorsal apex of femur and knee of tibia. (28) Middle leg colored like foreleg; spur entirely smooth, dark brown, length very long, about 0.8 length middle basitarsus, 0.53:0.60. (30) Tegula transparent, testaceous, with small anterior patch of cream (to yellow) color. Humeral plate testaceous. (32) Marginal cell (6-9) subequal to, and 3-4 shorter than 9-wt, 0.70:0.61:0.71.

Metasoma. (34) Tergal hair bands white. Band of tergum 1 narrowly (to broadly) interrupted medially, others entire. Suberect hair of disc of tergum 4 fulvous (to brownish), of disc of tergum 5 white (to fulvous). (35) Tergum 1 with punctures of median area exceedingly fine, dense, regularly spaced, 1-1.5 pwa, interspaces shiny though minutely roughened (60×), the tergum with a silky sheen (15×). Declivity of tergum 1 moderately shiny (to very shiny) though finely roughened.

Male. Length, 4.0 mm (type 4 mm); forewing length, 2.9 mm (type 2.8 mm); hindwing length, 2.2 mm; clypeal length, 0.32 mm; scutal length, 1.33 mm.

Head. White areas: (1) paraocular area below a line originating at dorsolateral rim of antennal socket and extending diagonally upward, passing below the facial fovea, to a point on orbit about 0.4 eye length below summit of eye; (2) clypeus, except for apical pale testaceous margin; (4) supraclypeal area, pentagonal shape, to level of upper rim of antennal socket; (5) subantennal plate. (7) Scape broadly yellow (to yellowish white) in front, the mesoapical portion brown; pedicel brown with a lateral yellow spot; dorsal surface of flagellum dusky, darker basad, with brown extending part way round flagellomeres 1, 2, and 3; ventral surface of flagellum tan, flagellomere 1 with a lateral yellow spot. (8) As in female. (10) Punctures of vertex and along ocellocular line with interspaces shiny but faintly roughened (60×). Median punctures of frons shallow, contiguous, dull. (11) Frontal line with lower portion carinate. (13) Orbital convergence ratio as 0.92:0.68,1.36. (14) Galea as in female. (15) Head width to head length as 1.39:1.12,1.24. (16) As in female. (17) Eye length, mio, and flagellar length as 0.83:0.68:1.41.

(18) Interocellar, ocellocular, antennocular, and interantennal as 0.26:0:26: 0.15:0.19. (19) Ocellolabral greater than clypeal width, 0:92:0.82,1.13. (20) Clypeocellar to outer subantennal sutural as 0.60:0.43,1.42. (21) Basal labial palpomere 0.7 times length of others combined. (22) Flagellar length about 4.0 times length of scape, 1.41:0.36.

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 2 mow. (24) Scutal and scutellar hairs whitish. Scutellar hair pads pale grayish-brown (to tan), their combined width slightly less than width of median portion of scutellum. Metanotal hair pads same color, broadly oval, failing to meet medially by less than mow, covering metanotum except for a median triangular area with base at anterior border of metanotum. Hair of metanotum white. (25) Scutal disc with punctures finer, deeper than on vertex, 2 or more pwa, interspaces shiny (60×). (26) Dorsal enclosure of propodeum with fine ridges originating anteriorly at the median line, each curving laterally along the width of the enclosure, giving the impression of tightly stretched, wrinkled skin. Remainder of propodeal triangle shiny. (27) Legs with light color bright yellow. Foreleg entirely yellow. (28) Middle leg with basal half of coxa dark, remainder of leg yellow with distitarsus pale testaceous. Lengths of tibia, basitarsus, and apicotarsus as 0.80: 0.85:1.00. (29) Hind leg colored like middle leg except distitarsus brown. Mediotarsomeres triangular in shape. (30) As in female. (32) Marginal cell lengths similar to female, 0.66:0.58:0.65.

Metasoma. (33, 34) As in female. (35) As in female except punctures 2 pwa.

Type Material. Holotype male from Picacho Pass (5 mi. S.E. of Picacho) [summit is at 1800 ft. altitude], Pinal Co., Arizona, Aug. 7, 1940 (P. H. Timberlake), on *Euphorbia,* is in the Timberlake collection at the University of California, Riverside, California. The above description of the male is based primarily on a topotypical specimen collected by C. D. Michener in company with Prof. Timberlake at the time of collection of the holotype.

Distribution. Known only from southern Arizona but to be expected from southwestern New Mexico and northern Sonora, southeastern California, and Baja California.

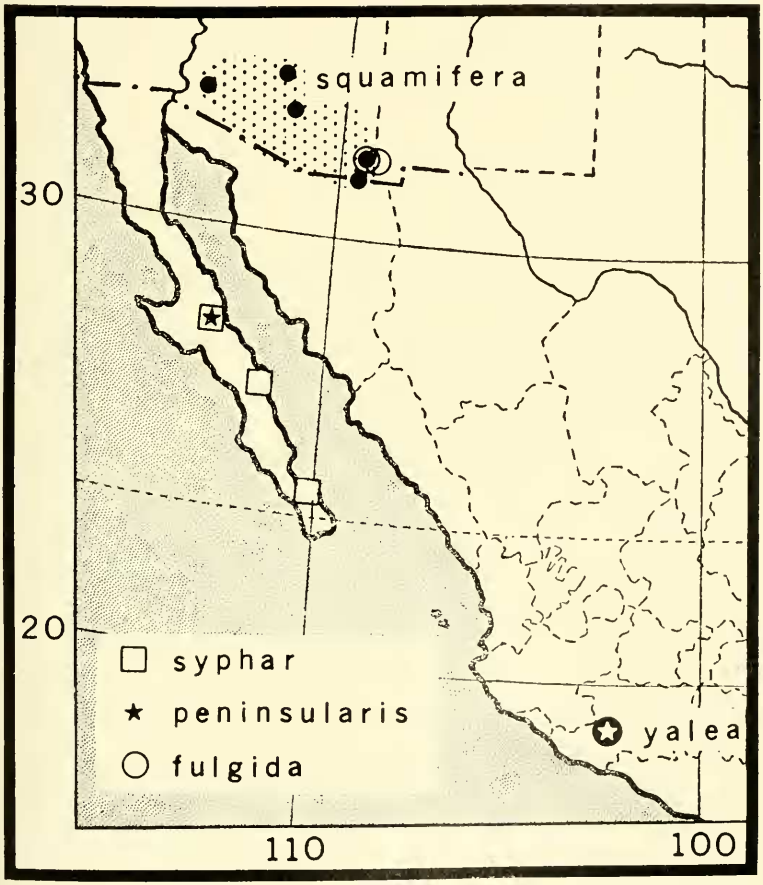
Specimens have been studied from the following localities: Arizona: Apache (5 mi. S.E.; 14 mi. S.W.), Cochise Co., Aug. 7-11, on *Euphorbia,* (13 mi. S.W.), Aug. 19-26, on *Euphorbia,* (5 mi. S.W.), Aug. 17, on *Baccharis glutinosa;* Douglas, Aug. 26 (3 mi. N.; 17 miles E.), Cochise Co., Aug. 8, on *Euphorbia;* Picacho Pass (5 mi. S.E. of Picacho), Pinal Co., Aug. 7, on *Euphorbia;* Portal (2 mi. N.E.), Cochise Co., Sept. 14; Roll, Yuma Co., July 11-Aug. 11, Oct. 20, on *Euphorbia* and Alfalfa; Tempe, Aug. 1.

Geographic Variation. Specimens from Roll in southwestern Arizona differ from those in middle southern and southeastern Arizona by having denser, shorter, more plumose hair on the face, thorax, and abdominal hair

bands. Females from Apache and Douglas have greatly reduced areas of cream color on the head. Other minor differences in certain head and thoracic dimensions occur, but without males I must consider these within the range of variation of the species.

Discussion. Most of the flower records are from *Euphorbia,* a biological datum bolstering the morphological data which indicate a relationship with *Perissander.*

Bionomics and Flower Records. Nothing is known of the bionomics of *squamifera,* but it has been taken on each one of the favorite plant families for the genus: Compositae, *Baccharis glutinosa;* Euphorbiaceae, *Euphorbia;* and Leguminosae, Alfalfa, *Medicago sativa.*



Map 3. Map showing the known distribution of *Calliopsis (Calliopsis) peninsularis* Shinn, *C. (C.) squamifera* Timberlake, *C. (Perissander) syphar* Shinn, *C. (P.) fulgida* Shinn, and *C. (P.) yalea* Shinn.

CALLIOPSIS (CALLIOPSIS) PENINSULARIS, new species

(Map 3)

The specific name is from the Latin, *peninsula,* because of occurrence on the peninsula of Baja California.

The species resembles *C. squamifera* and *C. syphar.* It is distinguished from the former by the much shorter, pectinate mesotibial spur, and from the latter by the distinctly reticulated ridges on the dorsal enclosure of the propodeum.

Female. Length, 5.5 mm; forewing length, 3.6 mm; hindwing length, 2.50 mm; clypeal length, 0.37 mm; scutal length, 0.90 mm.

Head. Cream colored areas: (1) paraocular area below a line originating at about middle of outer subantennal suture and extending dorsally, inclining slightly laterad, to about 1 mow above antennal socket then convexly curved upward passing just below facial fovea and ending on orbit about 0.4 times eye length below summit of eye; (2) clypeus with a broad, inverted T, the base bordering the supraclypeal area, the crossbar bordering the narrow, testaceous apical margin for almost full width of clypeus, thus isolating two subtriangular brown areas with bases along subantennal plates, and two tiny patches of brown in the extreme lower corners of clypeus; (4) as in *squamifera*; (5) subantennal plate. (8) As in *squamifera.* (10) As in *squamifera* except roughening confined to vertex and virtually undetectable (30×). (11) As in *squamifera.* (13) Orbital convergence ratio as 1.05:1.00,1.05. Facial fovea ellipsoidal, distinct, width a fourth to third of length. (14) As in *squamifera* except glossa less broad medially. (15) Head width to head length as 1.80:1.28,1.41. (17) Eye length, mio, and flagellar length as 1.04: 1.00:1.05. (18) Interocellar, ocellocular, antennocular and interantennal as 0.31:0.31:0.26:0.24. (19) Ocellolabral greater than clypeal width, 1.09:1.05,1.02. (20) Clypeocellar to outer subantennal sutural as 0.71:0.54,1.31. (21) Basal labial palpomere 0.8 times length of others combined. (22) Flagellar length about 2.3 times length of scape, 1.05:0.46.

Mesosoma. (23) Light areas cream colored; medial interruption of pronotal stripe about 1.5 mow. (24) Scutal, scutellar, and metanotal hair fulvous (may be faded!). (25) As in *squamifera* except punctures apicad from anterior end of parapsidal line becoming crowded to subconfluent with interspaces roughened. (26) Dorsal enclosure of propodeum with medial portion dull, bearing a distinct reticulum of ridges, lateral portion having about 7 longitudinal ridges with interspaces shiny (30×). Area of propodeal triangle adjacent to lateral areas of enclosure roughened but relatively shiny. (27) Legs with light color the same as on face. Foreleg with cream color on dorsal apex of femur and a slanting patch to slightly less than midpoint of tibia.

(28) Middle leg colored like foreleg except tibial patch extends only slightly beyond knee; spur finely, evenly pectinate, testaceous, its length to length of basitarsus as 0.34:0.61,0.55. (30) Tegula transparent, almost colorless, with small anterior patch of cream color. (32) Marginal cell 6-9 and 3-4 greater than 9-wt, 0.77:0.71:0.70.

Metasoma. (34) Tergal hair bands white, hairs longer, less dense, and less plumose than in *squamifera* or in *syphar*. Prepygidial and pygidial fimbriae smoky, denser and longer than *squamifera*. (35) Tergum 1 with punctures of median area fine, larger than *squamifera*, dense, regularly spaced, 1.0-1.5 pwa, interspaces shiny (30×), the tergum without a silken sheen (15×). Declivity of tergum 1 shiny, finely lineolate.

Type Material. Holotype female from San Ignacio (15 mi. N.), Baja California Sur, Sept. 29, 1941 (E. S. Ross and R. M. Bohart), is in the California Academy of Sciences, San Francisco.

CALLIOPSIS (CALLIOPSIS) SONORA, new species

(Figs. 34-37; Map 2)

The specific name is from the state of Mexico in which it occurs. It is closest to *hondurasica*. The female is distinguished from *hondurasica* by the smaller size and proportionately shorter flagellum relative to the minimum interocular distance. The male is distinguished by the smaller size and by the brown or gray metanotal hair pads which are separated by less than 1 mow.

Female. Length, 6.0 mm; forewing length, 4.2 mm; hindwing length, 2.90 mm; clypeal length, 0.46 mm, scutal length, 1.16 mm.

Head. Yellow areas: (1) paraocular area below a sinuous line originating at about middle of outer subantennal suture and passing below facial fovea ending on orbit slightly below facial fovea, well above antennal socket; (2) as in *hondurasica* except median stripe only 0.25 mow from clypeal apex; (4) as in *hondurasica;* (5) subantennal plate except uppermost portion. (8) Hair as in *hondurasica*. (10) Punctures along ocellocular line 1-2 pwa, fine but larger than *hondurasica,* interspaces dull but less so than in *hondurasica;* impunctate area laterally adjacent to posterior ocellus dull, roughened, but less so than in *hondurasica;* frontal punctures adjacent to upper frontal line as in *hondurasica* except interspaces very faintly metallic (30×). (12) Clypeus with punctures of disc larger than upper frontal ones, 2-3 pwa, interspaces roughened, except shiny in median apical portion. (13) Orbital convergence ratio, as 1.22:1.19,1.03. Facial fovea distinct, shorter than *hondurasica,* linear. (14) Galea smooth, shiny except faintly roughened basad; length shorter than antennocellar; galeal gap greater than length of galea exposed beyond closed mandibles. Hair of stipes as in *hondurasica*. (15) Head width to head length as 2.04:1.50,1.36. (17) Eye length, mio, and flagellar length as 1.12:1.19:1.21.

(18) Interocellar, ocellocular, antennocular, and interantennal as 0.37:0.37: 0.29:0.32. (19) Ocellolabral greater than clypeal width, 1.29:1.24,1.04. (20) Clypeocellar to outer subantennal sutural as 0.83:0.65,1.29. (21) Basal labial palpomere about 1.4 times length of others combined; ventral hairs as in *hondurasica* except smaller in diameter and fewer present. (22) Flagellar length about 2.2 times length of scape, 1.21:0.54.

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 2 mow. (24) As in *hondurasica.* (25) Scutal disc with punctures finer, shallower than in *hondurasica,* about 2 pwa, interspaces as in *hondurasica* except finer roughening. (26) Dorsal enclosure of propodeum as in *hondurasica.* (27) Foreleg as in *hondurasica.* (28) Middle leg colored like foreleg; spur length about 0.6 times length middle basitarsus, 0.44:0.73. (30) Tegula brown. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 0.90:0.70:0.85.

Metasoma. (34) Tergal hair bands white. (35) Tergum 1 with punctures of median area exceedingly fine, 2-3 pwa, interspaces dull, finely roughened.

Male. Length, 5.9 mm; forewing length, 4.0 mm; hindwing length, 2.81 mm; clypeal length, 0.43 mm; scutal length, 0.85 mm.

Head. Yellow areas (dull, not shiny like *hondurasica*): (1) paraocular area as described for subgenus, upper boundary relatively straight; (2) clypeus, dots colorless; frontoclypeal suture pale; (4) supraclypeal area, extending higher than in *hondurasica,* onto lower edge of frontal carina, summit slightly below level of upper border of antennal socket; (5) subantennal plate. (7) Scape, as in *hondurasica* except apex of triangular brown area only about 0.4 distance towards base of scape. Scape with length proportionately shorter than in *hondurasica.* (8) Hair as in *hondurasica.* (10) Punctures of upper frons fine, less so than *hondurasica,* less distinct than in *hondurasica,* 1 pwa, interspaces smooth, rather dull. (11) Frontal line with lower portion as in *hondurasica.* (13) Orbital convergence ratio as 1.17:0.99,1.19. (14) As in *hondurasica.* (15) Head width to head length as 1.87:1.53,1.22. (17) Eye length, mio, and flagellar length as 1.05:0.99:1.56. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.31:0.36:0.22:0.26. (19) Ocellolabral less than clypeal width, 1.22:1.26,0.97. (20) Clypeocellar to outer subantennal sutural as 0.80:0.61,1.30. (21) Basal labial palpomere 1.3 times length of others combined. (22) Flagellar length about 3.5 times length of scape, 1.56:0.44.

Mesosoma. (23) Light areas yellow. (24) As in *hondurasica.* Scutellar hair pads dark grayish brown, confined to entire lateral portion of scutellum, not completely hidden by base of wing. Metanotal hair pads same color, large, oval, separated by less than 1 mow. (25) Scutal disc punctures larger than in *hondurasica,* shallower, 1 pwa or less, interspaces as in *hondurasica.* (26) Dorsal enclosure of propodeum covered by metanotal hair pad except for medial portion which is gradually elevated; a single, prominent, mesally

oblique ridge on each side of the center line, enclosing area with several small, indistinct ridges. (27) Legs with light color the same as on face. Foreleg yellow except base of coxa brown. (28) Middle leg yellow except base of coxa brown, apicotarsus testaceous. (29) Hind leg yellow except base of coxa brown, dorsal apex of femur, and basal rim of basitibial plate testaceous, apicotarsus testaceous. (32) Marginal cell 6-9 subequal to, and 3-4 less than 9-wt, 0.77:0.61:0.78.

Metasoma. (34) As in *granti*. (35) Tergum 1 with punctures of median area very fine, indistinct, interspaces roughened, dull. (37) Sterna brown.

Type Material. Holotype male, from Rio Mayo, Sonora, Aug. 25, 1935 (collector unknown), is in Dr. G. E. Bohart's collection, Logan, Utah. Allotype female and one female paratype, from Rio Mayo, San Bernardino, Sonora, same date (J. J. du Bois), are at the University of California, Riverside, California.

Discussion. Apparently this species is an offshoot of *hondurasica* adapted to the arid Sonoran area where *hondurasica* does not occur.

One female specimen, from Canipole (about 100 mi. S.E. of San Ignacio), Baja California Sur, Oct. 2, 1941 (E. S. Ross and R. M. Bohart), may be this species. Its salient differences from the type material of *sonora* are the *presence* of a yellow spot on the tegula, basal labial palpomere 2.2 times length of others combined and 0.66 times length of scape, galeal length equal to scape length (much greater in *sonora*), interantennal less than antennocular, antennocular greater than inner subantennal sutural, scutal punctures shallower, less distinct, interspaces smoother and duller. Other characteristics are virtually identical, and this is so for numerous body measurements except the highly variable head width.

CALLIOPSIS (CALLIOPSIS) EMPELIA, new species

(Figs. 38-41; Map 2)

The specific name is from the Greek, *empelios,* meaning gray, which is applied with reference to the large gray metanotal hair pads.

It is closest to *sonora* and the female is distinguished from it by the yellow dot on the brown tegula, by the extremely dull interspaces between scutal punctures, by the non-metallic frons, and by the flagellar length being markedly shorter than the minimum interocular distance.

Female. Length, 7.2 mm; forewing length, 4.4 mm; hindwing length, 2.40 mm; clypeal length, 0.53 mm; scutal length, 1.27 mm.

Head. Yellow areas: (1) paraocular area as in *sonora;* (2) clypeus as in *hondurasica;* (4) supraclypeal area as in *sonora;* (5) subantennal plate entirely. (8) Hair faded, but as in *sonora.* (10) Punctures along ocellocular line coarser, shallower than others in *hondurasica* group, less than 1 pwa, inter-

spaces very dull, most coarsely roughened of *hondurasica* group; impunctate area dull, roughened; upper frontal punctures less than 0.5 pwa, interspaces heavily roughened. (12) Clypeus with punctures of disc about size of upper frontal punctures, 2-3 pwa, interspaces roughened, except shiny in median apical portion. (13) Orbital convergence ratio as 1.31:1.26,1.04. Facial fovea distinct, broader medially, tapering strongly above. (14) Galea faintly pebbled (30×); length less than antennocular; galeal gap subequal to length of galea exposed beyond closed mandibles. (15) Head width to head length as 2.30: 1.72,1.34. (17) Eye length, mio, and flagellar length as 1.26:1.26:1.02. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.36:0.39:0.32:0.31. (19) Ocellolabral greater than clypeal width, 1.45:1.39,1.03. (20) Clypeocellar to outer subantennal sutural as 0.92:0.70,1.31. (21) Basal labial palpomere 1.8 times length of others combined; ventral hairs somewhat thickened but much less than in *hondurasica*. (22) Flagellar length about 1.8 times length of scape, 1.02:0.56.

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 1.5 mow. (24) As in *andreniformis*. (25) Scutal disc with punctures of moderate size, much larger and closer than preceding species, 1 pwa or less, interspaces heavily roughened. (26) Dorsal enclosure of propodeum as in *hondurasica* except dull and more sharply carinate posteriorly. (27) Foreleg with yellow on extreme apex of femur. (28) Middle leg without yellow on extreme apex of femur; spur length about 0.64 times length of middle basitarsus. (30) Tegula brown with anterior yellow dot. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 1.11:0.85:1.00.

Metasoma. (34) Tergal hair bands white. (35) Tergum 1 with punctures of median area fine, about 1 pwa, interspaces heavily roughened, dullest of subgenus.

MALE. Length, 5.3 mm; forewing length, 4.0 mm; hindwing length, 2.89 mm; clypeal length, 0.41 mm; scutal length, 0.85 mm.

Head. Yellow areas: (1) paraocular area as described for subgenus, upper boundary relatively straight; (2) clypeus, dots black; frontoclypeal suture pale; (4) supraclypeal area, summit at level of upper border of antennal socket; (5) subantennal plate. (7) As in *hondurasica*, except brown area of scape extending to base of scape. (8) Hair as in *hondurasica*. (10) Punctures of upper frons almost as fine as in *hondurasica*, less distinct than in *hondurasica*, 1-2 pwa, interspaces smooth, dull. (11) Frontal line with lower portion as in *sonora* except lower. (13) Orbital convergence ratio as 1.11:0.90, 1.22. (14) Galea shiny, faintly pebbled, broader than *hondurasica* and *sonora*, tip less narrowly rounded; galeal gap greater than length of galea exposed beyond closed mandibles. (15) Head width to head length as 2.13:1.63,1.30. (17) Eye length, mio, and flagellar length as 0.99:0.90:1.79. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.29:0.34:0.20:0.24. (19) Ocel-

lolabral slightly less than clypeal width, 1.16:1.19,0.97. (20) Clypeocellar to outer subantennal sutural as 0.75:0.56,1.33. (21) Basal labial palpomere about 1.2 times length of others combined. (22) Flagellar length about 4.0 times length of scape, 1.79:0.44.

Mesosoma. (23) Light areas yellow. (24) As in *hondurasica*. Scutellar hair pad as in *sonora* except dark gray. Metanotal hair pad as in *sonora* except dark gray, contiguous medially on posterior border, separated anteriorly leaving a triangular area with broad apex from which arises a tuft of long white hairs. (25) Scutal disc with punctures as in *sonora* except interspaces shinier. (26) Dorsal enclosure of propodeum as in *sonora*. (27) Legs with light color the same as on face. Foreleg yellow except extreme base of coxa brown. (28) Middle leg colored like foreleg except apicotarsus testaceous. (29) Hind leg as in *hondurasica*. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 0.82:0.61:0.77.

Metasoma. (34) Tergal hair bands sparse but lateral portions somewhat more plumose and denser than other species of *hondurasica* group. (35) Tergum 1 with punctures of median area very fine, indistinct, interspaces roughened, somewhat shiny. (37) Sterna brown.

Type Material. Holotype male, from Mt. Lemmon Road, Mt. Lemmon, Arizona, 3500 ft., Aug. 15, 1954 (R. M. Bohart), and allotype female, from Douglas, Arizona, Aug. 2, 1940 (W. W. Jones), are in the Timberlake collection at the University of California, Riverside, California.

Discussion. The sexes were associated on the basis of punctation, sculpturing, similarity of mouthparts, and size difference as compared with that for *sonora* and *hondurasica*. The species probably occurs in that rich area for the genus—the Chiricahua Mountain region in the vicinity of Portal, Arizona.

CALLIOPSIS (CALLIOPSIS) ZORA, new species

(Map 2)

The specific name is from the Greek *zoros,* meaning strong, and is applied because this species is the largest and most robust bee in its subgenus.

Apparently closest to *empelia* from which it is distinguished by the completely brown tegula, by the moderately shiny interspaces between the scutal punctures, and by the faint greenish metallic color on the frons.

Female. Length, 7.5 mm; forewing length, 5.0 mm; hindwing length, 3.62 mm; clypeal length, 0.58 mm; scutal length, 1.38 mm.

Head. Yellow areas: (1) paraocular area as in *sonora* but ending on orbit at about level of upper rim of antennal socket; (2) clypeus with median stripe as in *hondurasica* except reaching to preapical groove; (3) labrum with median apical spot on labral plate; middle portion of labral plate strongly depressed, sunken well below usual level in *Calliopsis s.s.;* (4) supraclypeal

area, apex reaching to slightly above midlevel of antennal socket; (5) subantennal plate as in *empelia*. (8) Hair as in *hondurasica*. (10) Punctures along ocellocular line fine, 2 pwa, interspaces faint greenish metallic, moderately shiny; impunctate area laterally adjacent to posterior ocellus dull, finely roughened; upper frontal punctures extremely fine, indistinct, shallow, less than 1 pwa, interspaces faint greenish metallic, interspaces smooth, moderately shiny. (12) Clypeus with punctures of disc larger than upper frontal punctures, 2-3 pwa, interspaces roughened beside subantennal plate, shiny elsewhere (30×). (13) Orbital convergence ratio as 1.45:1.33,1.09. Facial fovea with indistinct mesal border, broader medially narrowed above and below. (14) Galea faintly pebbled basad; length subequal to antennocellar; galeal gap and length of galea exposed beyond closed mandibles N. A. (15) Head width to head length as 2.36:1.87,1.36. (17) Eye length, mio, and flagellar length as 1.33:1.33:1.33. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.34:0.44:0.32:0.36. (19) Ocellolabral greater than clypeal width, 1.55:1.43,1.08. (20) Clypeocellar to outer subantennal sutural as 0.97: 0.78,1.24. (21) Basal labial palpomere about 1.5 times length of others combined; ventral hairs thickened but less than in *hondurasica,* only 4-5 present. (22) Flagellar length about 2.2 times length of scape, 1.33:0.61.

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 4 mow. (24) Longer scutal and scutellar hairs dark brown, longer and more prominently branched than in preceding species. Hairs of metanotum fulvous, others as in *hondurasica*. (25) Scutal disc with punctures moderately large, about as in *empelia,* less than 0.5 pwa, interspaces shiny although finely roughened, punctures becoming crowded anteriorly, to contiguous. (26) Dorsal enclosure of propodeum shiny, with numerous fine, reticulated ridges; posterior border carinate, a small median portion of border raised distinctly upward; median portion about as long as lateral portion. (27) Foreleg without yellow on femur. (28) Middle leg colored like foreleg; spur length about 0.65 times length middle basitarsus. (30) Tegula blackish brown. (32) Marginal cell 6-9 less than, and 3-4 less than 9-wt, 1.04:0.88:1.09.

Metasoma. (34) Tergal hair bands white. (35) Tergum 1 with punctures of median area fine, about 1 pwa, interspaces moderately shiny, finely roughened.

Type Material. Holotype female, El Salto (6 mi. N.E.), Durango, México, 8500 ft., Aug. 10, 1947 (Gertsch, David Rockefeller Expedition), is in the American Museum of Natural History.

CALLIOPSIS (CALLIOPSIS) HELENAE, new species

(Map 1)

This species is named for my wife, Helen, who has helped in many ways to make the completion of this revision possible. The species has no apparent

close relative and is quite distinctive by virtue of the yellow markings on the lateral portions of the clypeus and on the tegula.

Female. Length, 6.5 mm; forewing length, 4.1 mm; hindwing length, 2.98 mm; clypeal length, 0.48 mm; scutal length, 1.16 mm.

Head. Cream colored areas: (1) paraocular area, below a sinuous line originating in upper half of outer subantennal suture and extending diagonally upward to a point on orbit about 0.4 of eye length below summit of eye; (2) clypeus with a broad, vertical median area from base bordering supraclypeal and subantennal areas to preapical groove and with irregular splotches contiguous to median area; (3) labrum with spot on apex of labral plate; (4) supraclypeal area to level of middle of antennal socket; (5) subantennal plate; (6) mandible possibly with a faint basal spot. (8) Hair on vertex, frons, and clypeus fulvous. (10) Punctures of vertex and along ocellocular line with interspaces shiny (30×). Median punctures of frons coarse, deep, less than 1 pwa, interspaces shiny (30×). (11) Frontal line with lower portion sulcate ending at level of middle of antennal socket. (13) Orbital convergence ratio as 1.22:1.19,1.03. Facial fovea elongate, length about 1.5 mow. (14) Galea entirely pebbled, galeal gap less than length of galea exposed beyond closed mandibles, 0.31:0.58. Glossa, length 1.62 (paratype). (15) Head width to head length as 2.06:1.65,1.25. (17) Eye length, mio, and flagellar length as 1.22:1.19:1.21. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.34:0.34:0.31:0.30. (19) Ocellolabral greater than clypeal width, 1.34:1.29, 1.32. (21) Basal labial palpomere about 2.0 times length of others combined. (22) Flagellar length about 2.3 times length of scape, 1.22:0.54.

Mesosoma. (23) Light areas cream colored; medial interruption of pronotal stripe about 2 mow. (24) Scutum and scutellum with short and long fulvous hairs (long hairs may be faded brown hairs!). Hair of metanotum fulvous. (25) Scutal disc with punctures fine, 2-3 pwa, interspaces shiny, smooth (30×), but roughened on anterior slope of scutum. (26) Dorsal enclosure of propodeum with median portion a dull reticulum of close transverse ridges, the lateral portion shiny with ridges becoming longitudinal. (27) Legs with light color the same as on face. Foreleg with cream color on dorsal apex of femur and knee of tibia. (28) Middle leg colored like foreleg; spur finely, uniformly pectinate; length of spur to basitarsal length of paratype as 0.46:0.71,0.69. (30) Tegula transparent testaceous with anterior patch of cream color. (32) Marginal cell 6-9 and 3-4 both shorter than 9-wt, 0.82: 0.75:0.87.

Metasoma. (34) Tergal hair bands moderately dense, white, appressed. (35) Tergum 1 with punctures of median area finer than on scutum, mostly 2 pwa, interspaces shiny (30×). Declivity of tergum 1 finely lineolate. (37) Sternum 6 brown without a median, clear, subcircular area.

Type Material. Holotype female, Alice (10 mi. S.), Texas, July 17, 1956 (University of Kansas Mexican Expedition), is in the Snow Entomological Museum at The University of Kansas. One female paratype, Piedras Negras, Coahuila, 1300 ft., Aug. 25, 1949 (G. M. Bradt), is at the American Museum of Natural History.

Subgenus PERISSANDER Michener

Perissander Michener, 1942, New York Ent. Soc. Jour., 50:275; Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric., Monogr. No. 2:1104.
Type species. Calliopsis anomoptera Michener, 1942, monobasic and original designation.

This subgenus seems to be a derivative of the *hondurasica* group of *Calliopsis s.s.* The entire subgenus is restricted to the arid northwestern Mexico and southwestern United States. The species prefers flowers of *Euphorbia* to which the short, stubby mouthparts seem adapted. *Calliopsis gilva, C. fulgida,* and *C. yalea* are slightly different from the *anomoptera* group (which includes *rogeri, syphar,* and *limbus*) largely by reason of the elongate cylindrical glossae. The floral records for *gilva* and *fulgida* include *Verbesina* and *Tidestromia,* members of the Compositae and Amaranthaceae, respectively, which also suggest an ecological separation from the *anomoptera* group.

Perissander differs from the other subgenera as follows. Males lack the scutellar and metanotal hair pads, yet have the type of genital capsule described for *Calliopsis s.s.* Both males and females have the galeae hidden in repose by the closed mandibles, or in *gilva, fulgida,* and *yalea* have the length of the galea exposed beyond closed mandibles less than 1 mow. The peculiar, flat, short, truncate glossa of the *anomoptera* group occurs elsewhere only in *squamifera* and *peninsularis.*

Female. Length, 4.5-7.5 mm.

Head. Light colored areas: (1) paraocular area below a line originating on outer subantennal suture slightly below its upper origin, and extending laterally from 0.50-0.75 times width of paraocular area, thence dorsally to, or close to, lower margin of facial fovea, thence laterally ending on orbit at level of it; in *gilva,* upper border runs sinuously from about midpoint of outer subantennal suture (to near upper end) to lower border of facial fovea ending at level above it on orbit. (2) Clypeus with a median area with base adjacent to frontoclypeal suture, shape variable, from a relatively narrow horizontal strip or trianguliform area, to longitudinal band with laterally expanded base, length about 0.66 times length of clypeus; *gilva* with spot in lower lateral corner; (3) absent on labrum; (4) supraclypeal area pentagonal or semilunar with apex at or below midlevel of antennal socket; (5) subantennal plate; (6) absent on mandible (basal dot in *fulgida* and *yalea*). (7) Scape and pedicel brown to black, flagellum dark above, tan below on at least apical 7 flagellomeres. (8) Hair on vertex, frons, and clypeus variable, of gena white.

(10) Punctures along ocellocular line variable, interspaces variable; impunctate area lateral to posterior ocellus shiny (roughened and dull in *limbus*); punctures of frons with shiny interspaces (roughened in *limbus*). (11) Frontal line with lower portion a sharp carina or a finely sulcate carina. (12) Clypeus with punctures of disc somewhat eccentric; disc very little protuberant; apical portion adjacent to medial area bent about 45° posteriad as seen from below, projection of apical border smoothly rounded, not tooth-like. (13) Inner orbits subparallel to divergent below. Facial fovea shallow to deep, smaller than in other subgenera, usually oval. (14) Galea short, not visible with mandibles closed except in *gilva, fulgida,* and *yalea,* where length of galea exposed beyond closed mandibles is less than 1 mow. Glossa flat, short, truncate, abruptly broadened medially, flabellum absent except in *gilva, fulgida,* and *yalea* which have short, cylindrical, flabellate glossae. (15) Head width/head length 1.3-1.5. (17) Eye length slightly less than mio, subequal to or more than a tenth less than flagellar length. (18) Antennocellar about twice antennocular; interocellar two-thirds of, to equal to ocellocular. (19) Ocellolabral equal to or greater than mio, subequal to clypeal width. (21) Basal labial palpomere slightly less than, or subequal to, length of others combined in *anomoptera* group, about 1.7 times length of others in *gilva*. (22) Flagellomere 1 slightly shorter than flagellomere 9. Flagellar length 2.1-2.8 times length of scape.

Mesosoma. (23) Light colored areas: medial interruption of pronotal stripe 2-3 mow; apex of pronotal lobe; scutellar crest. (24) Scutal and scutellar hairs of two kinds, longer ones fulvous to black, shorter ones fulvous. (25) Scutal disc with punctures distinct, interspaces polished to dulled by fine roughening. (26) Dorsal enclosure of propodeum variously sculptured, always with some ridges, often quite low. (27) Legs with light color the same as on face. Foreleg as in *Calliopsis s.s.* (28) Middle leg as in *Calliopsis s.s.*, except spur of *gilva* almost bare, with a few coarse teeth apicad. (29) Hind leg brown (yellow band on trochanter of *yalea*). (30) Tegula brown to transparent straw color, with anterolateral patch of yellow or cream color. Humeral plate brown, or testaceous with apical half yellow. (31) Wing at least partly smoky apically beyond cells. Stigma brown. (32) Marginal cell 6-9 variable, 3-4 less than 9-wt.

Metasoma. (34) Tergal hair bands white, dense, appressed. Band of tergum 1 broadly interrupted medially, of tergum 2 much less so, of other terga complete, except all bands complete on *rogeri,* white to fulvous. Suberect hair of discs of terga 4-5 dark brown to black. Prepygidial and pygidial fimbriae smoky to dark brown. (35) Tergum 1 with punctures of median area subequal to or smaller than those on scutum, uniformly distributed, distinct, interspaces dull to shiny. Declivity of tergum 1 variable. (37) Sterna orange-red, brown, or black.

Male. Length, 4.0-5.5 mm.

Head. Light colored areas: (1) paraocular area upper limit varying between lower and upper border of facial fovea, in latter case indented by facial fovea; (2) clypeus; (3) labrum; (4) supraclypeal area apex between three-fourths length of scape above upper rim of antennal socket to about 0.02 mm below middle ocellus, joined with paraocular area to make a continuous light colored area; (5) subantennal plate; (6) base of mandible; (7) scape, pedicel (tan dorsally in *limbus*), flagellomere 1, remaining flagellomeres tan. (8) Hair of vertex, frons, and clypeus white or fulvous. (10) Punctures of upper frons, fine, dense, fairly regularly distributed, 1 pwa or less. (11) Frontal line with lower portion as in female. (13) Inner orbits moderately convergent below. Facial fovea tiny, less than area of middle ocellus in some cases. (14) Galea as in female. (15) Head width/head length 1.2-1.4. (17) Eye length subequal to or greater than mio; flagellar length variable. (18) Interocellar to ocellocular variable; antennocular equal to or greater than interantennal. (21) Basal labial palpomere 0.5-1.8 times length of others combined. (22) As in female but flagellar length 3.1-3.8 times length of scape.

Mesosoma. (23) Light colored areas: as in female but also ventral surface of mesosoma extending upward to lower third or half of mesepisternum. (24) Hair as in female except long and short scutal and scutellar hairs concolorous. Scutellar and metanotal hair pads absent. (25) Scutal disc with punctures deep and distinct, or shallow and indistinct; interspaces smooth or finely roughened. (26) Dorsal enclosure of propodeum with fine ridges, vertical triangular portion delimited very faintly. (27) Legs with light color the same as on face. Foreleg yellow except minute spot of brown on posterior dorsal surface of trochanter, distitarsus testaceous. (28) Middle leg colored like foreleg except brown trochanteral spot larger, apicotarsus testaceous. (29) Hind leg colored like middle leg. (30) Tegula brown to colorless with anterior patch or spot of yellow. Humeral plate basally brown, apically yellow. (31) Wing with apical portion beyond cells clear to distinctly light brown to naked eye. Costal vein testaceous to yellowish white. Stigma pale testaceous. (32) As in female.

Metasoma. (34) Similar to female. (35) Tergum 1 with punctures variable. (36) Pygidial plate sunken medially, broadly rounded to somewhat truncate apically. (37) Sternal color similar to that of female. Shapes of sterna 5, 6, and 8 similar to those in *Calliopsis s.s.* (38) Sterna and genitalia as illustrated (Figs. 46-57).

CALLIOPSIS (PERISSANDER) ANOMOPTERA Michener

(Figs. 7, 46-49; Map 4)

Calliopsis (Perissander) anomoptera Michener, 1942, Jour. New York Entom. Soc., 50: 275-277; Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric., Monogr. No. 2: 1104; Krombein, 1961, Ent. News, 72: 82-83 (biology).

The specific name obviously was applied because of the anomalous shape of the apical portion of the wing of the male which is unique among the

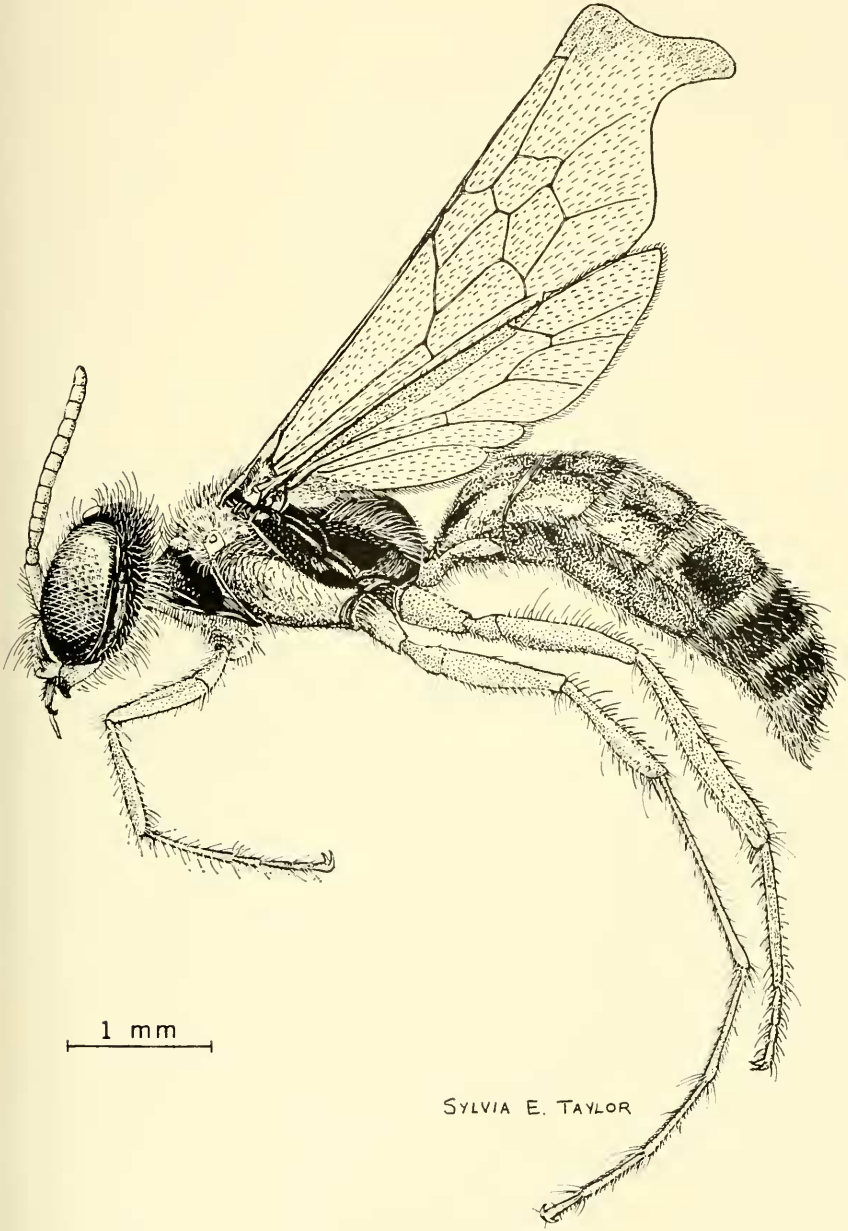


Fig. 7. Lateral view of male *Calliopsis (Perissander) anomoptera* Michener. Note the great elongation of the middle tarsus which is characteristic of the subgenus.

Apoidea. The closest relative is *rogeri* from which *anomoptera* is readily distinguished by the larger size and by the orange or orange-red metasomal terga. In fact, *anomoptera* is distinguished from all other species of *Calliopsis* by the orange or orange-red metasoma.

Female. Length, 5.5 mm; forewing length, 3.6 mm; hindwing length, 2.4 mm; clypeal length, 0.34 mm; scutal length, 0.78 mm.

Head. Integumental background color black (faintly metallic in some specimens). Yellow areas: (1) paraocular area below a sinuous line originating slightly below upper origin of outer subantennal suture and extending concavely upward to ventral margin of facial fovea and laterally to a point on the orbit about same level which is about 0.4 of eye length below summit of eye; (2) clypeus with a subtriangular spot with base bordering supraclypeal area and apex reaching about 0.6 of distance to clypeal apex (to all yellow except for brown splotching along apical margin medially; (7) scape brown (some specimens with extreme apex and base including basal bulb pale testaceous). (8) Hair of vertex, frons, and clypeus fulvous. (10) Punctures of midvertex and along ocellocular line fine, 1-2 pwa, interspaces shiny (30×). (11) Frontal line with lower portion carinate, ending in a slightly raised prominence at level of upper rim of antennal socket. (13) Orbital convergence ratio as 1.00:0.97,1.04. Facial fovea ellipsoidal, short, only slightly longer than mow, length to width as 0.17:0.09. (15) Head width to head length as 1.60:1.16,1.39. (17) Eye length, mio, and flagellar length as 0.90:0.97:0.90. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.27:0.44: 0.27:0.22. (19) Ocellolabral subequal to clypeal width, 0.97:0.99. (20) Clypeocellar to outer subantennal sutural as 0.63:0.46,1.37. (21) Basal labial palpomere subequal to length of others combined. (22) Flagellar length about 2.1 times length of scape, 0.90:0.42.

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 2 mow. (24) Scutum and scutellum with numerous short, fulvous hairs and less numerous, long, brownish hairs. Hair of metanotum fulvous medially, white laterad. (25) Scutal disc with punctures fine, 1-2 pwa, interspaces shiny, smooth (30×). (26) Dorsal enclosure of propodeum with curved lines radiating anterolaterad from the median apical border, interspaces shiny, remainder of propodeum smooth, highly polished. (27) Foreleg with yellow on extreme dorsal apex of femur (sometimes absent) and basal third to half of tibia. (28) Middle leg colored like foreleg except tibial yellow slightly less extensive; spur finely, evenly pectinate, testaceous, its length slightly less than half of basitarsal length, 0.29:0.60. (30) Tegula transparent, straw colored with anterior patch of yellow. Humeral plate testaceous with small patch of light color. (32) Marginal cell 6-9 and 3-4 both longer than 9-wt, 0.76:0.70:0.66.

Metasoma. (33) Terga 1-4 reddish-orange, sometimes with irregular patches of reddish-black, tergum 4 often with posterior margin black; terga 5-6 black. (35) Tergum 1 with punctures of median area much finer than on scutum, densely, regularly distributed, less than 1 pwa, interspaces shiny (30×). Declivity of tergum 1 somewhat shiny. (37) Sterna orange except sternum 6 dark brown to black.

Male. Length, 5.1 mm; forewing length, 4.5 mm; hindwing length, 3.0 mm; clypeal length, 0.34 mm; scutal length, 0.75 mm.

Head. Yellow areas: (1) paraocular area ending between middles of facial foveae, indented by them, or extending above facial foveae, surrounding them continuous with supraclypeal area; (4) supraclypeal area and entire frons to about 0.02 mm below middle ocellus. (13) Orbital convergence ratio as 1.00:0.87,1.15. Facial fovea ovoid, tiny, a fourth to third area of middle ocellus. (15) Head width to head length as 1.65:1.24,1.33. (17) Eye length, mio, and flagellar length as 0.94:0.87:1.29. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.27:0.29:0.22:0.20. (19) Ocellolabral subequal to clypeal width, 0.99:1.00,1.00. (20) Clypeocellar to outer subantennal sutural as 0.65:0.46,1.41. (21) Basal labial palpomere about 0.66 times length of others combined. (22) Flagellar length about 3.6 times length of scape, 1.29:0.36.

Mesosoma. (23) Yellow area of mesepisternum usually covering approximately lower half, sometimes with yellow reaching pronotal lobe. (24) Short scutal hairs many-branched, appearing moss-like and partially hiding surface viewed from directly above. (25) Scutal disc with punctures fine, deep, distinct, 2 pwa, interspaces smooth, shiny. (26) Dorsal enclosure of propodeum declivous, sunken, with rolled porterior border; median portion much longer than lateral portions, with fine ridges originating in strong emargination along posterior border, diverging laterally towards anterior border; lateral portions with low, fine ridges separated by about 2 ridge widths, interspaces slightly roughened but shiny. (28) Length of middle tibia, basitarsus, mediotarsus, and apicotarsus as (0.95:1.21:1.38:1.65), basitarsus distinctly shorter than mediotarsus, ratio of tibia to basitarsus 0.79. (30) Tegula colorless to pale straw color with anterior yellow patch. (31) Forewing of unique shape among Apoidea (Fig. 6), apical portion beyond marginal cell bent abruptly posteriad, drawn into a broad, posteriorly-directed tip, brown apical portion in form of a band. Costal vein yellowish white. (32) Marginal cell long, very slender, parallel-sided apically, 6-9 about 3 times, and 3-4 about 2 times greater than 9-wt, 1.09:0.85:0.39; 11-12 less than 0.7 times 13-14.

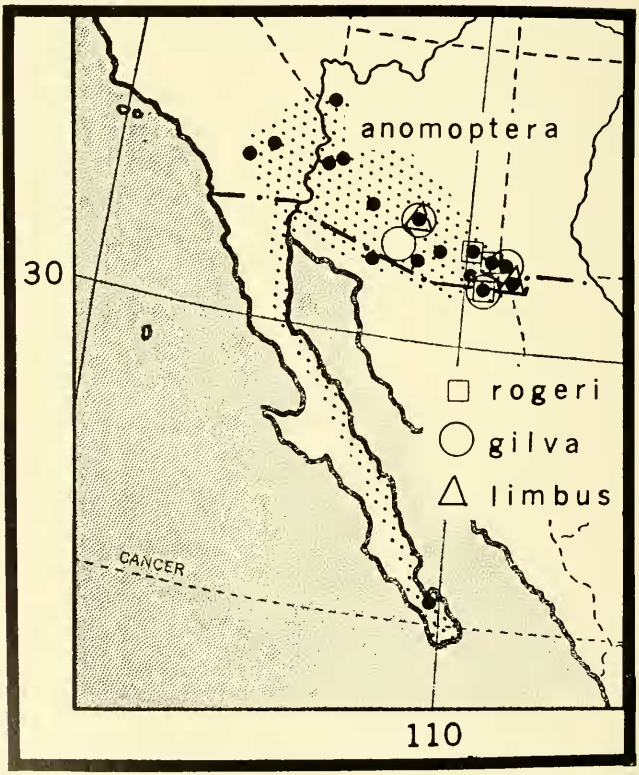
Metasoma. (33) Terga 1-3 orange, sometimes with reddish-brown areas; tergum 2 with lateral fovea reddish-brown; terga 4-6 reddish-brown to black. (35) Tergum 1 with punctures of median area fine, distinct, regularly dis-

tributed, 0.5 pwa or less, interspaces smooth, dull (30×). (37) Sterna orange, except sternum 8 dark brown.

TYPE MATERIAL. Holotype male and allotype female from Picacho Pass, Arizona, Aug. 7, 1940 (C. D. Michener), on a small *Euphorbia,* are at the American Museum of Natural History. The above description of the female is primarily based on a specimen from Douglas (1 mi. E), Arizona, Aug. 16, 1962 (M. Statham), and that of the male on a paratype specimen.

DISTRIBUTION. The southwestern United States and northwestern Mexico, including Baja California. It occurs from the first week of July to the last week of September in New Mexico and Arizona, and has been taken in California from early September to early October. The latest date of capture is at La Paz, Baja California Sur, on Oct. 10, 1955 (F. X. Williams). It is a sonoran desert form which occurs where *Euphorbia* flourishes.

Approximately 255 specimens were examined from the following localities which include the type: ARIZONA: Apache (5 mi. S.E.), Cochise Co.; Brenda (2 mi. W.), Yuma Co.; Douglas (1, 17 mi. E.; 3 mi. N.; 16 mi. N.E.), Cochise Co.; Gila Bend (18 mi. S.), Maricopa Co.; Kingman (10



MAP 4. Map showing the known distributions of *Calliopsis (Perissander) anomoptera* Michener, *C. (P.) rogeri* Shinn, *C. (P.) gilva* Shinn, and *C. (P.) limbus* Shinn.

mi. N.W.), Mohave Co.; Lowell (5 mi. E.), Cochise Co.; Picacho Pass; Portal, Chiricahua Mts., Cochise Co.; Sabino Canyon, near Tucson; Santa Rita Mts., 5000 ft. to 8000 ft.; Sells, Pima Co.; Tucson (10, 23 mi. S.); Wenden; Willcox, Cochise Co. California: Palm Springs, Riverside Co.; Twentynine Palms. New Mexico: Granite Pass, Hidalgo Co.; Rodeo (11, 18 mi. N.), Hidalgo Co.; Rodeo, Cienaga Lake, Hidalgo Co.; Willow Creek Mts. Baja California: La Paz. Sonora: Sonoita (26 mi. E.).

Bionomics. This species is one of several which favor *Euphorbia* for a food plant for both pollen and nectar. Krombein (1961) reported that he found it in abundance on *Euphorbia albomarginata* from July 23 to 31, 1959, and that P. D. Hurd collected it at the same place and flower August 9 to 15, 1958, both at Portal, Arizona, 4000 ft. altitude, near the S. W. R. S., American Museum of Natural History. Krombein *(op. cit.)* mentioned that only males were taken on July 23 and 24, most of them newly emerged, and that freshly emerged females were present on the flowers on July 26th. Two of the females captured bore pollen masses composed entirely of *Euphorbia* pollen.

Flower Records. *Cladothrix lanuginosa, Eriogonum, Euphorbia albomarginata, E. capitellata, E. hirtella, E. pleniradiata, E. polycarpa hirtella, E. polycarpa typica, Lepidium thurberi, Tidestromia.*

CALLIOPSIS (PERISSANDER) ROGERI, new species

(Figs. 50-53; Map 4)

I take pleasure in naming this smallest species of *Calliopsis* after my son, Roger, who has helped me in many ways during the study, both in the field and the laboratory.

The species is closest to *anomoptera* and *syphar*, but both sexes are readily distinguished from *anomoptera* by their black, metallic integument, and total absence of any trace of integumental orange-red color. The male of *syphar* is unknown but the female of *rogeri* differs from that of *syphar* by the strong brassy tints on head, mesosoma, and especially the metasomal terga.

Female. Length, 4.6 mm; forewing length, 3.1 mm; hindwing length, 2.2 mm; clypeal length, 0.31 mm; scutal length, 0.82 mm. Integumental background color black with faint greenish metallic tint on head, strong brassy metallic tint on mesosomal dorsum, very strong brassy tint on metasomal terga.

Head. Yellow areas: (1) paraocular area as described for subgenus; (2) clypeus with T-shaped median figure, ventral end of shaft of T extending to middle of clypeus (T often filled in to form a triangular patch). (8) Hair of vertex, frons, and clypeus fulvous. (10) Punctures along ocellocular line fine, dense, regularly distributed, 1 pwa, interspaces shiny. (11) Frontal line with lower portion a finely sulcate carina. (13) Orbital convergence ratio as 1.02: 0.94,1.09. Facial fovea ovoid, short, only slightly longer than mow. (15) Head width to head length as 1.56:1.12,1.39. (17) Eye length, mio, and flagellar

length as 0.83:0.94:0.88. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.31:0.25:0.27:0.18. (19) Ocellolabral equal to clypeal width, 0.95: 0.95,1.00. (20) Clypeocellar to outer subantennal sutural as 0.65:0.44,1.46. (21) Basal labial palpomere about 0.85 times length of others combined. (22) Flagellar length about 2.2 times length of scape, 0.88:0.39.

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 2 mow. (24) Scutal black hairs twice length of short, fulvous hairs, or more. (25) Scutal disc with punctures almost hidden, viewed from above, by plumosity of short, fulvous hairs; punctures fine, deep, distinct, 1-2 pwa, interspaces shiny, metallic. (26) Dorsal enclosure of propodeum with fine, low ridges originating along posterior, median border, passing anterolaterally in parallel, symmetrical, curves. (27) As in *anomoptera* but only basal fourth to third of tibia yellow. (28) Middle leg colored like foreleg; spur evenly, finely pectinate, length of spur about half of basitarsal length, 0.27:0.56. (30) Tegula brown with anterolateral patch of yellow. Humeral plate brown. (32) Marginal cell 6-9 subequal to, and marginal cell 3-4 distinctly shorter than 9-wt, 0.68:0.53:0.66.

Metasoma. (34) All tergal hair bands complete. (35) Tergum 1 with punctures of median area smaller than on scutum, very fine, dense, regularly distributed, 0.5 pwa, interspaces moderately shiny. Declivity of tergum 1 dull. (37) Sterna black (to dark brown).

Male. Length, 4.5 mm; forewing length, 3.3 mm; hindwing length, 2.15 mm; clypeal length, 0.34 mm; scutal length, 0.65 mm.

Head. Yellow areas: (1) paraocular area extending to lower border of facial fovea, indented by it (usually), continuous with supraclypeal area; (4) supraclypeal area extending above to same level as (to slightly below) paraocular yellow, both well below middle ocellus. (11) Frontal line with lower portion a sharper carina than in *anomoptera*. (13) Orbital convergence ratio as 0.95:0.82,1.16. Facial fovea ovoid to tear drop shaped, area about half area of middle ocellus. (15) Head width to head length as 1.50:1.11,1.35. (17) Eye length, mio, and flagellar length as 0.82:0.82:1.11. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.26:0.29:0.23:0.17. (19) Ocellolabral greater than clypeal width, 0.94:0.90,1.03. (20) Clypeocellar to outer subantennal sutural as 0.60:0.53,1.40. (21) Basal labial palpomere about 0.85 times length of others combined. (22) Flagellar length about 3.4 times length of scape, 1.11:0.32.

Mesosoma. (23) Yellow area of mesepisternum covering somewhat less than lower half, less extensive than in *anomoptera*. (24) As in *anomoptera* except denser. (25) As in *anomoptera* but punctures 1 pwa. (26) Dorsal enclosure of propodeum subhorizontal, not sunken, posterior border weakly or not defined; median portion as in *anomoptera*, lateral portions roughened with few mesally oblique ridges. (28) Lengths of middle tibia, basitarsus,

mediotarsus, and apicotarsus as 0.78:0.97:1.19:1.36, basitarsus distinctly shorter than mediotarsus, ratio of tibia to basitarsus 0.81, about as in *anomoptera*. (30) Tegula pale straw color with anterior yellow patch. (31) Forewing normal, brown apical portion in form of a round spot, slightly flattened on side toward wing base. Costal vein pale testaceous. (32) Marginal cell 6-9 longer than, and 3-4 shorter than 9-wt, 0.71:0.58:0.66; 11-12 equal to or only slightly shorter than 13-14.

Metasoma. (33) Terga black with brassy tints. (34) As in female. (35) Tergum 1 with punctures of median area fine, shallower and not so distinct as in *anomoptera,* less regularly distributed, 0.5 pwa or less. Interspaces roughened, dull (30×). (37) Sterna brown to black.

Type Material. Holotype male and allotype female from Douglas (1 mile E.), Cochise Co., Arizona, Aug. 16, 1962 (M. Statham), are at the American Museum of Natural History.

Twelve male and 10 female paratypes were collected at the following localities: Arizona: Apache (5 mi. S.E.), Cochise Co., 1 male, Aug. 11, 1958 (D. D. Linsdale), 5 males, same date (R. M. Bohart), *Euphorbia; idem* (14 mi. S.W.), 2 males, 2 females, Aug. 7, 1961 (J. G. Rozen), *Euphorbia;* Douglas (1 mi. E.), Cochise Co., 2 males, 1 female, Aug. 16, 1962 (M. Statham); *idem* (3 mi. N.), 4 males, 1 female, Aug. 4, 1961, *Euphorbia,* 2 males, 2 females, Aug. 8, 1961 (all J. G. Rozen); *idem* (17 mi. E.), 1 male, Aug. 4, 1958 (D. D. Linsdale); *idem,* 4 males, 1 female, Aug. 8, 1958, *Euphorbia,* 1 male, same date, *Lepidium thurberi* (all P. D. Hurd); *idem,* 2 females, Aug. 8, 1958 (R. M. Bohart), *Euphorbia;* Lowell (5 mi. E.), Cochise Co., 1 male, Aug. 15, 1958 (P. M. Marsh); Portal, Cochise Co., 1 male, Aug. 12, 1958 (P. D. Hurd), *Euphorbia; idem,* 1 female, July 23-31, 1959 (K. V. Krombein), *Euphorbia albomarginata; idem* (2 mi. N.E.), "Site B", 1 female, Sept. 25, 1961 (M. A. Cazier); Willcox, Cochise Co., 1 male, Aug. 14, 1958 (D. D. Linsdale), *Euphorbia; idem* (1 mi. S.), 1 female, Sept. 8, 1959 (G. I. Stage). Paratypes will be deposited in the collection of P. H. Timberlake, University of California, Riverside, California, the California Academy of Science, the University of California at Berkeley, the American Museum of Natural History, and the personal collections of Dr. Karl V. Krombein of the U.S. National Museum, Mr. Roy E. Snelling, Los Angeles, California, and The University of Kansas, Lawrence.

Distribution. Known only from the southeastern corner of Arizona but probably will be found in at least the adjacent parts of México and New Mexico. Its flight season is in August and September.

Flower Records. *Euphorbia albomarginata, E.* sp., and *Lepidium thurberi.* It has been taken with *Calliopsis anomoptera* on these plants. A study of the competition between these two species would be enlightening.

CALLIOPSIS (PERISSANDER) SYPHAR, new species

(Map 3)

The specific name is derived from the Greek, *sypharos,* meaning wrinkled skin, in allusion to the appearance of the dorsal enclosure of the propodeum which suggests the wrinkled character of the elephant's skin. The specimens exhibit strong similarities to *C. (Perissander) rogeri,* notably in the characteristic of the dorsal enclosure of the propodeum, though expressed more strongly than in *rogeri. C. syphar* is readily distinguished from *rogeri* by the

non-metallic integument, larger size, proportionately longer mesotibial spur, and by the marginal cell 6-9 being about the same length as 3-4 and 9-wt.

Female. Length, 5.5 mm; forewing length, 3.5 mm; hindwing length, 2.5 mm; clypeal length, 0.39 mm; scutal length, 0.85 mm.

Head. Cream colored areas: (1) paraocular area below a line originating at upper end of outer subantennal suture and extending horizontally to about midline of area thence curving sharply upward to level of lower margin of facial fovea, ending on orbit about half eye length below summit of eye. (2) Clypeus with a broad T-shaped maculation (to only the vertical stem of T present), the crossbar of the T along the border of the supraclypeal area (to along supraclypeal area and both subantennal plates), the vertical stem extending about two-thirds of distance to clypeal apex. (8) Hair of vertex fulvous (to light brown), twice length of longer scutal hairs, of frons and clypeus fulvous. (10) As in *rogeri*. (11) Frontal line with lower portion a barely discernible (30×) sulcus becoming obsolete about midlength of scape, frontal prominence with a minute point. (13) Orbital convergence ratio as 1.11:1.07, 1.02. Facial fovea ovoid, very shallow, width about half length, shallower and broader than *rogeri*. (15) Head width to head length as 1.75:1.22,1.43. (17) Eye length, mio, and flagellar length as 0.97:1.07:1.05. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.34:0.31:0.31:0.22. (19) Ocellolabral slightly greater than clypeal width, 1.09:1:04,1.05. (20) Clypeocellar to outer subantennal sutural as 0.70:0.51,1.36. (21) Basal labial palpomere about 1.1 times length of others combined. (22) Flagellar length about 2.4 times length of scape, as 1.05:0.44.

Mesosoma. (23) Light areas cream colored; medial interruption of pronotal stripe about 2 mow. (24) As in *rogeri*. (25) Scutal disc with punctures finer than in *rogeri*, deep, about 2 pwa, interspaces shiny, smooth. (26) Dorsal enclosure of propodeum with fine lines radiating anterolaterad from the median apical border as in *rogeri* but more pronounced, numerous, longer, and originating along a broader part of rear border of dorsal enclosure, interspaces roughened, and remainder of propodeal triangle finely roughened. (27) Foreleg with cream color on dorsal apex of femur and basal third of tibia, tarsus brown. (28) Middle leg colored like foreleg; spur linely, evenly pectinate, testaceous, its length about 0.6 times basitarsal length, 0.37:0.61. (30) Tegula transparent, almost colorless, with small anterior patch of cream color. Humeral plate testaceous. (32) Marginal cell 6-9 and 3-4 greater than 9-wt, 0.73:0.71:0.68.

Metasoma. (35) Tergum 1 with punctures of median area smaller than on scutum, densely, regularly distributed, 1 pwa or less, interspaces shiny (30×). Declivity of tergum 1 finely lineolate, shiny. (36) As in *rogeri*.

Type Material. Holotype female from San Ignacio (15 mi. N.), Baja California Sur, Sept. 29, 1941 (E. S. Ross and R. M. Bohart) is in the California Academy of Sciences, San Francisco.

Five female paratypes are from the localities below: Baja California Sur: Canipole, 2 females, Oct. 2, 1941 (Ross and Bohart); La Paz, 1 female, Oct. 10, 1955 (F. X. Williams); San Ignacio (15 miles N.), 1 female, Sept. 29, 1941 (Ross and Bohart); San Pedro, 1 female, Oct. 7, 1941 (Ross and Bohart).

CALLIOPSIS (PERISSANDER) LIMBUS, new species

(Map 4)

The species name is from the Latin, *limbus,* meaning border, in reference to its occurrence near the Mexican and United States borders. It is closest to *C. rogeri* but the male is readily distinguished from *rogeri* by the faintly smoky wing tip and the finely roughened interspaces between mesoscutal punctures. The abdomen of the male holotype is missing. Both the female allotype and single female paratype are the same species, but since they were not collected with the male, the association of the sexes is tentative. The female of *limbus* differs from that of *rogeri* by the higher ratio of flagellar length to scape length (average 2.7 to 2.3 for *rogeri*), by the marginal cell 6-9 being less than 9-wt, and by the lack of metallic sheen on the dorsum of the thorax and abdomen.

Female. Length, 4.4 mm; forewing length, 3.1 mm; hindwing length, 2.19 mm; clypeal length, 0.34 mm; scutal length, 0.82 mm.

Head. Pale yellow areas: (1) paraocular area as described for subgenus; (2) clypeus, narrow strip extending along frontoclypeal suture between middles of subantennal plates, with a broad, ventrally directed median projection of light color. (8) Hair of vertex, frons, and clypeus white. (10) Punctures along ocellocular line as in *rogeri* except interspaces roughened, impunctate area beside lateral ocellus roughened. (11) Frontal line with lower portion a low, sharp carina. (13) Orbital convergence ratio as 0.97:0.95,1.02. Facial fovea elliptical, minute, area smaller than that of lateral ocellus; length slightly greater than mow. (14) Glossa narrower medially than that of *rogeri,* shape somewhat intermediate between *rogeri* and *fulgida.* (15) Head width to head length as 1:53:1.16,1.32. (17) Eye length, mio, and flagellar length as 0.87:0.95:1.02. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.29:0.29:0.27:0.20. (19) Ocellolabral slightly greater than clypeal width, 1.00:0.95,1.05. (20) Clypeocellar to outer subantennal sutural as 0.66:0.44,1.50. (21) Basal labial palpomere 1.8 times length of others combined. (22) Flagellar length about 2.5 times length of scape, 1.02:0.39.

Mesosoma. (23) Light areas pale yellow; medial interruption of pronotal stripe 1-2 mow. (24) Scutal dark hairs only slightly longer than short, fulvous

hairs. (25) Scutal disc with punctures not obscured by hair; punctures finer than in *rogeri*, 2 pwa, interspaces faintly roughened, shiny, becoming crowded with more distinct roughening of interspaces anteriad. (26) Dorsal enclosure of propodeum with about 18 longitudinal or obliquely longitudinal ridges with interspaces heavily roughened. (27) Foreleg with yellow on extreme dorsal apex of femur and base of tibia. (28) Middle leg colored like foreleg; spur evenly, finely pectinate, length of spur about 0.6 (to 0.5) times basitarsal length, 0.31:0.51. (30) Tegula pale brown with anterolateral patch of pale yellow. Humeral plate pale brown. (32) Marginal cell 6-9 less than, and 3-4 much less than 9-wt, 0.63:0.53:0.68.

Metasoma. (35) Tergum 1 with punctures of median area very fine, dense, regularly distributed, 0.5 pwa, interspaces roughened, quite dull. Declivity of tergum 1 as in *rogeri*. (37) Sterna black.

Male. Length, N. A. (abdomen missing); forewing length, 3.3 mm; hindwing length, 2.4 mm; clypeal length, 0.34 mm; scutal length, 0.78 mm.

Head. Yellow areas: (1) paraocular area as in *rogeri* but separated from supraclypeal area by intervening black less than 0.02 mm wide at antennal socket; (4) supraclypeal area extending above to a level 0.8 mow below summit of paraocular yellow. (11) Frontal line with lower portion as in *rogeri*. (13) Orbital convergence ratio as 1.04:0.90,1.15. Facial fovea elliptical, area about half of area of middle ocellus. (15) Head width to head length as 1.53: 1.22,1.25. (17) Eye length, mio, and flagellar length as 0.88:0.90:1.14. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.29:0.32:0.26:0.22. (19) Ocellolabral longer than clypeal width, 1.02:0.97,1.05. (20) Clypeocellar to outer subantennal sutural as 0.68:0.46,1.48. (21) Basal labial palpomere about 1.1 times length of others combined. (22) Flagellar length about 3.2 times length of scape, 1.14:0.36.

Mesosoma. (23) Yellow area of mesepisternum covering less than lower one-third, less extensive than either *rogeri* or *anomoptera*. (24) As in *rogeri*. (25) Scutal disc with punctures fine, shallow, larger than *rogeri* or *anomoptera*, 1 pwa, interspaces finely roughened, moderately shiny. (26) Dorsal enclosure of propodeum subhorizontal, slightly sunken, posterior border defined by low carina; median and lateral portions with numerous, slightly vermiform, longitudinal ridges separated by 1-2 ridge widths, dull. (28) Lengths of middle tibia, basitarsus, mediotarsus, and apicotarsus as 0.83:0.94: 0.99:1.17, basitarsus only slightly shorter than mediotarsus, ratio of tibia to basitarsus 0.89, higher than in *rogeri* and *anomoptera*. (30) Tegula pale straw color with anterior yellow patch. (31) Forewing normal, apical portion beyond cells clear to naked eye, slightly smoky beyond marginal cell (30×). Costal vein pale testaceous. (32) Marginal cell 6-9 and 3-4 both shorter than 9-wt, 0.68:0.56:0.75; 11-12 slightly longer than 13-14.

Metasoma. Missing.

Type Material. Holotype male from Sabino Canyon, near Tucson, Arizona, July 31, 1941 (L. H. Banker), and allotype female from Granite Pass, 15 mi. N.E. Rodeo, Hidalgo Co., New Mexico, Aug. 25, 1958 (P. D. Hurd), on *Euphorbia,* are in the Snow Entomological Museum at The University of Kansas, Lawrence, and at the University of California, Berkeley, respectively. One female paratype, Mt. Lemmon Road, Arizona, 3500 ft. altitude, Aug. 15, 1954 (R. M. Bohart), is at the University of California, Riverside.

Distribution. Known only from southeastern Arizona and southwestern New Mexico.

Flower Records. *Euphorbia.*

CALLIOPSIS (PERISSANDER) GILVA, new species

(Figs. 54-57; Map 4)

The specific name from the Latin, *gilvus,* meaning pale yellow, is applied in reference to the large amount of pale yellow color on the male face, antenna, and legs.

The species is closest to *limbus.* The female is readily separated from all others of the genus by its unique mesotibial spur which is bare except for 2-4 coarse teeth on the apical four-tenths; both male and female are separated from *limbus* by the shiny, non-roughened interspaces on the head and scutum. The male is readily separated from *limbus* also by the non-metallic integument on the body.

Female. Length, 7.5 mm; forewing length, 4.4 mm; hindwing length, 3.1 mm; clypeal length, 0.49 mm; scutal length, 1.19 mm.

Head. Yellow areas: (1) paraocular area below a sinuous line originating at about middle (to upper origin) of outer subantennal suture and extending obliquely upward ending on orbit about 0.4 of eye length below summit of eye, slightly above lower rim of facial fovea; (2) clypeus with a vertical stripe from margin below supraclypeal area to within less than mow of apex, width of stripe slightly less than width of supraclypeal area (and a small dot in lower corner of clypeus in some specimens); (8) Hair of vertex and clypeus both brown and fulvous, of frons fulvous. (10) Punctures of midvertex with interspaces shiny, along ocellocular line 2 pwa, interspaces shiny (30×). Median punctures of frons fine, deep, mostly 1 pwa, interspaces shiny (30×). (11) Frontal line with lower portion sulcate, ending at level of middle of antennal socket. (13) Orbital convergence ratio as 1.36:1.34,1.01. Facial fovea elongate, length about 2 mow. (14) Galea pebbled apically, shiny medially, length exposed beyond closed mandibles to galeal gap as 1.10:0.56. (15) Head width to head length as 2.23:1.62,1.38. (17) Eye length, mio, and flagellar length as 1.24:1.34:1.22. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.37:0.39:0.37:0.31. (19) Ocellolabral less than clypeal width, 1.34:

1.41,0.95. (20) Clypeocellar to outer subantennal sutural as 0.85:0.70,1.22. (21) Basal labial palpomere about 1.5 times length of others combined. (22) Flagellar length about 2.2 times length of scape, 1.22:0.57.

Mesosoma. (23) Light areas yellow; medial interruption of pronotal stripe about 2 mow. (24) Scutum and scutellum with similarly sized, short fulvous hairs and brown hairs twice as long. Hair of metanotum fulvous except long, posteriorly directed hair whitish. (25) Scutal disc with fine punctures mostly 1 pwa, interspaces shiny, smooth (30×). (26) Dorsal enclosure of propodeum a reticulum of fine, vermiform ridges, dull medially but with interspaces shiny laterad, remainder of propodeal triangle shiny. (27) Foreleg with yellow on extreme dorsal apex of femur and knee of tibia. (28) Middle leg colored like foreleg; spur bare basally, with three sharp teeth on apical 0.4; length of spur about 0.7 times basitarsal length, 0.56:0.83. (30) Tegula transparent testaceous with anterior patch of yellow. Humeral plate testaceous, broadly margined with yellow. (32) Marginal cell 6-9 slightly longer than, and 3-4 much shorter than 9-wt, 0.90:0.65:0.88.

Metasoma. (35) Tergum 1 with punctures of median area finer than on scutum, somewhat irregularly distributed, less than 1 pwa, interspaces shiny (30×). Declivity of tergum 1 finely lineolate. (37) Sterna brown.

Male. Length, 4.7 mm; forewing length, 3.7 mm; hindwing length, 2.6 mm; clypeal length, 0.37 mm; scutal length, 0.80 mm.

Head. Yellow areas: (1) paraocular area as in *limbus* (to broadly continuous with supraclypeal area); (4) supraclypeal area extending above to level of summit of paraocular yellow (to 0.02-0.03 mm below). (11) Frontal line with lower portion as in *rogeri*. (13) Orbital convergence ratio as 0.99: 0.82,1.20. Facial fovea elliptical, less distinct than in other *Perissander* species, area as in *limbus*. (15) Head width to head length as 1.65:1.24,1.33. (17) Eye length, mio, and flagellar length as 0.95:0.82:1.39. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.31:0.31:0.20:0.20. (19) Ocellolabral greater than clypeal width, 1.05:0.97,1.09. (20) Clypeocellar to outer subantennal sutural as 0.68:0.44,1.54. (21) Basal labial palpomere about 1.7 times length of others combined. (22) Flagellar length about 3.7 times length of scape, 1.39:0.37.

Mesosoma. (23) Yellow area of mesepisternum covering approximately lower half (variable, from less than lower third to more than lower half). (24) Short scutal hairs not many-branched, not moss-like nor partially hiding surface viewed from directly above. (25) As in *anomoptera*. (26) Dorsal enclosure of propodeum subhorizontal, slightly sunken, with rolled posterior border, area much reduced compared with other *Perissander* species; median and lateral portions with numerous, slightly vermiform, longitudinal ridges separated by 1 ridge width, moderately shiny. (28) Lengths of middle tibia, basitarsus, mediotarsus, and apicotarsus as 0.97:1.11:0.87:1.09, basitarsus dis-

tinctly longer than mediotarsus, slightly longer than (to subequal to) apicotarsus, ratio of tibia to basitarsus 0.87. (30) Tegula pale straw color with anterior yellow patch (to spot). (31) Forewing normal, apical portion beyond cells faintly smoky to naked eye. Costal vein yellowish white basally to testaceous apically. (32) Marginal cell 6-9 subequal to, and 3-4 much shorter than 9-wt, 0.78:0.58:0.77.

Metasoma. (35) Tergum 1 with punctures of median area fine, larger than in other species of *Perissander,* deep, distinct, regularly distributed, 0.5-1 pwa, interspaces smooth, shiny (30×). Declivity of tergum 1 somewhat shiny. (37) Sterna brown.

Type Material. Holotype male from Douglas (17 mi. E.), Cochise Co., Arizona, August 8, 1958 (R. M. Bohart), on *Euphorbia,* is in the collection of P. H. Timberlake at the University of California, Riverside, California. Allotype female from Douglas (1 mi. E.), Arizona, August 16, 1962 (M. Statham), is at the American Museum of Natural History.

Two male and seven female paratypes were collected from the following localities: Arizona: Douglas (1 mi. E.), 4 females, Aug. 16-17, 1962 (M. Statham); Quijotoa (30 mi. E.), Pima Co., 1 male, 1 female, Aug. 28-29, 1927 (Cornell University, Lot 542 Sub 336); Tucson (10 mi. S.), 1 male, Aug. 7, 1940 (C. D. Michener), on *Verbesina.* New Mexico: Rodeo (4.5 mi. N.), Hidalgo Co., 1 female, Aug. 21, 1962 (J. G. Rozen, M. Statham, S. J. Hessel); *idem* (4.8 mi. N), 1 female, Sept. 4, 1961 (P. D. Hurd), on *Tidestromia lanuginosa.* Paratypes will be deposited at Cornell University, the Snow Entomological Museum of The University of Kansas, the University of California at Berkeley, the American Museum of Natural History, and in the author's collection.

Distribution. Known only from southeastern Arizona and southwestern New Mexico. Its flight season is August and early September, which is similar to that of *rogeri* and *limbus.*

Flower Records. *Euphorbia, Verbesina,* and *Tidestromia lanuginosa.* These records represent three families, viz., Euphorbiaceae, Compositae, and Amaranthaceae. Although taken mostly on *Euphorbia,* this bee apparently visits other plants, perhaps more extensively than *Euphorbia.* Its mouthparts are short as in the other species of *Perissander,* but the glossa is cylindrical and the labial palp is much longer and with segments of different proportions than the other species. A comparison of mouthparts of *Euphorbia*-visiting bees to discover the adaptations necessary for visiting this flower would be interesting.

CALLIOPSIS (PERISSANDER) FULGIDA, new species

(Map 3)

The specific name is from the Latin *fulgidus,* meaning shining, and is applied because of the overall high lustre of the black integument—the shiniest of the genus. Its closest relative is *gilva,* from which it is easily distinguished by the impunctate posterior area on the first metasomal tergum. It is distinguished from all other species of *Calliopsis s.s.* and *Perissander* by the impunctate posterior area on metasomal tergum 2 as well. A fundamental

difference between *fulgida* and *gilva* occurs in the mouthparts. *C. fulgida* has a cylindrical, flabellate glossa which is shorter than the maxillary palp, whereas *gilva* has the same type of glossa but it is distinctly longer than the maxillary palp.

Female. Length, 6.4 mm; forewing length, 4.3 mm; hindwing length, 3.1 mm; clypeal length, 0.48 mm; scutal length, 1.02 mm.

Head. White to cream colored areas: (1) paraocular area below a sinuous line originating at about middle (to upper origin) of outer subantennal suture and extending diagonally upward ending on orbit about 0.4 of eye length below summit of eye, slightly above level of lower rim of facial fovea; (2) clypeus with a median T-shaped mark (one arm of crossbar partially missing in type), the crossbar adjacent to supraclypeal and subantennal areas, the vertical portion reaching to preapical groove; small dots adjacent to apical border laterally; (6) mandible with a faint basal dot. (8) Hair of vertex and clypeus both brown and fulvous, of frons fulvous. (10) Punctures of midvertex with interspaces shiny, along ocellocular line 3 pwa, interspaces shiny (30×), both areas with punctures finer than in *gilva*. Median punctures of frons finer than *gilva,* 2 pwa, interspaces shiny (30×). (11) Frontal line with lower portion sulcate, much wider and deeper than in *gilva*. (13) Orbital convergence ratio as 1.24:1.21,1.03. Facial fovea as in *gilva*. (14) Galea pebbled, length exposed beyond closed mandibles to galeal gap as 0.07:0.56 (0.09:0.44). (15) Head width to head length as 2.06:1.51,1.36. (17) Eye length, mio, and flagellar length as 1.16:1.21:1.09. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.39:0.32:0.34:0.31. (19) Ocellolabral slightly shorter than clypeal width, 1.28:1.29,0.99. (20) Clypeocellar to outer subantennal sutural as 0.77:0.54,1.40. (21) Basal labial palpomere about 1.5 times length of others combined. (22) Flagellar length about 2.1 times length of scape, 1.09:0.51.

Mesosoma. (23) Light areas cream colored; medial interruption of pronotal stripe 1.8 mow. (24) As in *gilva* except brown hairs faded to fulvous on type. (25) Scutal disc with fine punctures 2-3 pwa, interspaces highly polished (30×). (26) Dorsal enclosure of propodeum with longitudinal, shiny ridges and interspaces, remainder of propodeal triangle highly polished. (27) Foreleg with cream color as in *gilva*. (28) Middle leg colored like foreleg; spur with about 7 fine, uniformly-spaced teeth, length of spur about 0.6 times basitarsal length, 0.43:0.68. (30) Tegula transparent testaceous with anterior patch of cream color. Humeral plate as in *gilva*. (32) Marginal cell 6-9 longer than, and 3-4 shorter than 9-wt, 0.90:0.77:0.85.

Metasoma. (35) Tergum 1 with punctures of anterior half of median area finer than on scutum, 1-3 pwa, of posterior half virtually absent, interspaces highly polished. Declivity of tergum 1 smooth, finely punctate. (37) As in *gilva*.

Type Material. Holotype female, from Rodeo (4.8 mi. N.), Hidalgo Co., New Mexico., Sept. 4, 1961 (P. D. Hurd), on *Tidestromia lanuginosa,* is in the collection of the California Insect Survey, University of California, Berkeley. One female paratype from Portal (5 mi. E.), Arizona, Sept. 16, 1956 (G. E. Bohart), on *Euphorbia,* is in the collection of the collector at Logan, Utah.

Discussion. P. D. Hurd has taken both *gilva* and *fulgida* on *Tidestromia,* and both have been taken on *Euphorbia,* records which support the placement of *fulgida* as a close relative of *gilva.*

CALLIOPSIS (PERISSANDER) YALEA, new species

(Map 3)

The specific name is from the Greek, *yaleos,* meaning highly polished. The species has no close affinities and although the facial marking is similar to *C. syphar,* it is readily distinguished from *syphar* by the much larger size. The stout setae of the ventral surface of the basal labial palpomere are similar to those of the *Calliopsis hondurasica* group, but they are much shorter, thicker, and straighter.

Female. Length, 7.5 mm; forewing length, 5.2 mm; hindwing length, 3.5 mm; clypeal length, 0.59 mm; scutal length, 1.36 mm.

Head. Yellowish areas: (1) paraocular area below a line originating on outer subantennal suture about at level of middle of antennal socket and extending dorsally 0.03 mm then laterally slightly more than half width of area, curving concavely upward to just below facial fovea and ending on orbit about at level of lower border of facial fovea, 0.44 times length of eye below summit of eye; lower mesal portion of area somewhat tumid; (2) clypeus with a broad T-shaped area adjacent to subantennal plates and supraclypeal area, the lower part of vertical bar 2 times mow, extending to within 0.5 mow of clypeal apex; (6) mandible, a more or less indistinct spot. (8) Hair of vertex brown, of frons white, of clypeus both fulvous and brown. (10) Punctures of midvertex with interspaces roughened, along ocellocular line of mixed sizes, 1-2 pwa, interspaces slightly roughened. (11) Frontal line with lower portion a sulcus, frontal prominence ending about level of middle of antennal socket. (13) Orbital convergence ratio as 1.53:1.46,1.04. Facial fovea as in *syphar.* (14) Galea shiny, length exposed beyond closed mandibles to galeal gap as 0.15:0.65. (15) Head width to head length as 2.50:1.87,1.32. (17) Eye length, mio, and flagellar length as 1.39:1.46:1.33. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.43:0.43:0.39:0.36. (19) Ocellolabral less than clypeal width, 1.55:1.63,0.95. (20) Clypeocellar to outer subantennal sutural as 0.97:0.77,1.26. (21) Basal labial palpomere about 1.7 times length of others combined; seven stout setae ventrally on basal five-eighths, two additional setae paired apically, the mesoapical seta longer, thicker, all setae pro-

portionately shorter and thicker than those of *Calliopsis (C). hondurasica* group. (22) Flagellar length about 2.1 times length of scape, 1.33:0.65.

Mesosoma. (23) Light areas yellowish; medial interruption of pronotal stripe about 2 mow. (24) Scutal and scutellar longer hairs brown, others N. A. Hair of metanotum white. (25) Scutal disc with punctures very fine, 1 pwa, interspaces shiny. (26) Dorsal enclosure of propodeum with medial portion dull with fine, low, interconnecting ridges, lateral portions shiny with a few prominent, shiny ridges. (27) Legs with light color the same as on face. Foreleg with a narrow yellow band on ventral apex of trochanter, yellow on dorsal apex of femur and basal fourth to third of tibia. (28) Middle leg colored like foreleg; spur finely, evenly pectinate, testaceous, its length about 0.5 times basitarsal length, 0.49:0.97. (29) Hind leg brown except trochanter colored as in foreleg but band narrower. (30) Tegula transparent, testaceous, with small anterior patch of yellow. Humeral plate brown. (32) Marginal cell 6-9 longer than, and 3-4 slightly shorter than 9-wt, 1.05:0.90:0.92.

Metasoma. (35) Tergum 1 with punctures of median area about the same size as on scutum, densely, regularly distributed, 1-2 pwa, interspaces shiny (30×). Declivity of tergum 1 rather dull with numerous fine punctures. (37) Sterna dark brown.

TYPE MATERIAL. Holotype female, from Apatzingan (11 miles E.), Michoacan, Aug. 20, 1954 (E. G. Linsley, J. W. MacSwain, and R. F. Smith), is in the California Academy of Sciences, San Francisco.

Subgenus CALLIOPSIMA, new subgenus

Type species. Calliopsis rozeni Shinn.

This subgenus is composed of closely related species which are sharply separated from the other subgenera. No specimens which might represent annectent forms have been discovered. Several species of the South American panurgine genus *Acamptopoeum* have color markings almost identical with the males of many species of *Calliopsima*. The deep, distinct punctures with smooth, shiny interspaces found in *Calliopsima* are also typical of *Acamptopoeum*. *Calliopsima* seems to have a mixture of the characters found in *Acamptopoeum* and *Calliopsis s.s.*, and is judged to be closest to *Calliopsis s.s.*

Four groups of species occur within this subgenus. They are: 1) the *crypta* group including *rozeni, unca, azteca,* and *chlorops;* 2) the *pectidis* group including *timberlakei* and *bernardinensis;* 3) the *coloratipes* group including *deserticola, pugionis,* and possibly *coloradensis;* and 4) the *hurdi* group including *quadridentata* and *kucalumea*.

Calliopsima occurs only from Canada to near the border between Mexico and Guatemala. The locality for *Acamptopoeum* which is closest to this area is for *A. colombiensis* Shinn (Shinn, 1965) in northern Colombia. [The

record of *A. maculatum* (Smith) in Florida is almost certainly erroneous.] *Calliopsima* predominately visits flowers of the Compositae and Leguminosae.

The males of *Calliopsima* differ from those of *Calliopsis* and *Perissander* by the relatively flat clypeus, the non-tumid paraocular area, and the different shapes of the posterior projections of sterna 5 and 8. Sternum 5 of *Calliopsima* has a relatively large median, posterior projection which is club-shaped or parallel-sided; sternum 8 has a long, slim club-shaped projection. The females differ from those of *Calliopsis* and *Perissander* by the white to amber prepygidial and pygidial fimbriae (smoky in *hurdi* group) and the light hairs of the discs of terga 4-5 (a few brown hairs occasionally). Both sexes differ from the above subgenera by having maxillary palpomere 2 longer than 3, and by having coarse, deep, pleural punctures with smooth, usually shiny interspaces.

Female. Length 6.5-10.0 mm.

Head. Light colored areas: (1) paraocular area below a sinuous line originating between middle of outer subantennal suture and upper end of suture and extending diagonally upward to lower inner margin of facial fovea, thence laterally, tangent to fovea, ending on orbit well above level of upper border of antennal socket, usually about level of middle of facial fovea; very shiny; (2) clypeus variable from completely yellow except for two small clypeal dots, to yellow on lateral portions with a median longitudinal band extending from frontoclypeal suture a variable distance towards the clypeal apex; (3) labrum variable, all black to yellow; (4) supraclypeal area pentagonal to trianguliform with apex between middle of and a third mow above antennal socket; (5) subantennal plate variable, black to yellow; (6) mandible with basal portion variable. (7) Scape reddish brown to blackish brown dorsally (except basal and apical yellow areas in *timberlakei*), pedicel and dorsal surface of flagellum brown to black extending part way onto ventral surface of flagellomeres 1-4, or latter all black, remaining flagellomeres tan ventrally. (8) Hair of vertex colorless or mixed light and dark, or all dark, of frons whitish, of clypeus fulvous. (10) Punctures along ocellocular line medium sized to very fine. Interspaces shiny; impunctate area, lateral to posterior ocellus shiny; punctures beside lower half of frontal line fine to large, interspaces smooth, dull to shiny. (11) Frontal line with lower portion a narrow, sulcus, sometimes interrupted, rising gradually to a low summit on frontal prominence between antennal sockets slightly above their midline. (12) Clypeus with punctures of disc more distinct than in *Calliopsis s.s.*, clypeus relatively much flatter than in *Calliopsis s.s.* but somewhat protruding in *deserticola*. Projections beside apical emargination of clypeus smoothly rounded. (13) Inner orbits slightly convergent below. Facial fovea deep, upper end slightly below middle ocellus, lower end about 1 mow above level of upper border of antennal socket, somewhat tear-drop shaped or broadened

medially, tapered above and below. (14) Galea of moderate length, proportionately longer than in *Calliopsis s.s.* (except *hondurasica* group). Galeal gap less than inner subantennal sutural. (15) Head width/head length 1.2-1.5. (17) Eye length subequal to or less than mio or flagellar length. (18) Interocellar subequal to ocellocular except greater in *pectidis* group; antennocular greater than interantennal (less than in *deserticola*). (19) Ocellolabral subequal to or greater than clypeal width except distinctly less in *hurdi*. (21) Basal labial palpomere 2.1-3.3 times length of others combined. *Maxillary palpomere 2 longer than 3.* (22) Flagellomere 1 about twice length of flagellomere 2, subequal to flagellomere 9; flagellar length 2.0-2.3 times length of scape.

Mesosoma. (23) Light colored areas: medial interruption of pronotal stripe 0.5-3 mow, variable within species; apex pronotal lobe, sometimes absent; scutellar crest variable. (24) Scutal and scutellar hairs of two kinds, longer ones fulvous to black, shorter ones fulvous. Hairs of scutellar crest and of posterolateral border of metanotum as in *Calliopsis s.s.* (25) Scutal disc with punctures deeper, mostly larger, more distinct than in *Calliopsis s.s.*, interspaces smooth, either shiny or dull. (26) Dorsal enclosure of propodeum with longitudinal ridges, sometimes vermiform, posterior border at least carinate laterally, medial portion usually prolonged posteriorly, interspaces shiny. (27) Foreleg with at least basal spot of yellow on tibia, on apex of femur (absent in *hurdi* and *kucalumea*), and on base of basitarsus in *pectidis* group. (28) Middle leg colored like foreleg. Spur with extremely minute teeth or without evident teeth (20×), covered with fine, abundant, short fulvous or white hair. (29) Hind leg usually brown except yellowish on apex of femur and base of tibia in *pectidis, timberlakei,* and some specimens of *bernardinensis.* (30) Tegula colorless to dark brown with light colored anterior patch or spot. Humeral plate brown or light colored apically. (31) Wing slightly smoky (to naked eye or at 30×) apically beyond cells. Stigma testaceous to brown. (32) Marginal cell 6-9 greater than (subequal to in *pectidis*), and 3-4 much less than (subequal to or greater than in *deserticola, bernardinensis,* and *kucalumea*) 9-wt.

Metasoma. (34) Tergal hair bands white, appressed, dense to sparse. Band of tergum 1 broadly interrupted, of tergum 2 less so (except both may be continuous in *pectidis* and *bernardinensis*). Suberect hair of discs of terga 4-5 whitish to fulvous, a few brown hairs in some cases. Prepygidial and pygidial fimbriae white to fulvous (smoky in *hurdi* group). (35) Tergum 1 with punctures of median area as in *Calliopsis s.s.* but interspaces shiny to highly polished (dull in *hurdi*), puncture size variable with respect to punctures on scutum. Declivity of tergum 1 with a highly polished mirror-like surface, bearing few to no punctures.

Male. Length, 5.2-8.0 mm.

Head. Yellow areas: (1) paraocular area as in female, except upper border usually straight, mesal origin of dorsal boundary line usually higher than in corresponding female, yellow ending in more of a point on orbit; (2) clypeus with testaceous apical border; (3) labrum; (4) supraclypeal area as in female; (5) subantennal plate in some cases with small black area, black border, or all black (some *hurdi*); (6) mandible a basal spot to basal two-thirds; (7) scape entirely, through lesser amounts of yellow, to all brown; pedicel, sometimes; flagellum as in female except lighter throughout, flagellomeres 1-3 sometimes yellow. (8,10) As in female. (11) Frontal line with lower portion a slightly elevated, low, non-sulcate, somewhat rounded, never sharp, rather broad ridge, summit as in female. (12) As in female. (13) Inner orbits moderately to strongly convergent below. Facial fovea usually distinct. (14) As in female. (15) Head width/head length 1.30-1.48. (17) Eye length greater than (barely so in *hurdi* and *quadridentata*) mio, and much less than flagellar length. (18) Interocellar subequal to ocellocular (greater in *timberlakei, bernardinensis,* less in *hurdi, kucalumea, quadridentata*); antennocular less than interantennal; antennocellar subequal to outer subantennal sutural. (21) Basal labial palpomere 1.6-3.2 times length of others combined. *Maxillary palpomere 2 longer than 3.* (22) As in female except flagellar length 2.8-3.3 times length of scape.

Mesosoma. (23) Yellow areas as in female, except more extensive, richer yellow. (24) As in female unless otherwise stated. (25) Scutal disc with punctures deeper, larger, more distinct than in *Calliopsis s.s.*, more abundant than in female, interspaces smooth, dull or shiny. (26) Dorsal enclosure of propodeum similar to that of female except median portion more prolonged and ridges usually straighter, farther apart. (27) Legs with light color the same as on face. Foreleg with highly variable color pattern among species. (28) Middle leg colored like foreleg, but less extensive light color. (29) Hind leg usually colored like middle leg. (30) As in female (*azteca, hurdi,* and *kucalumea* without light color on tegula). (31) As in female. (32) Marginal cell 6-9 greater than, and 3-4 equal to or less than (more than, in *hurdi, kucalumea, quadridentata*) 9-wt; 11-12/13-14 variable.

Metasoma. (34) As in female. (35) Tergum 1 with punctures of median area as described for *Calliopsis s.s.*, tergum sometimes dull; puncture size smaller than to larger than that of scutum. Declivity of tergum 1 usually smooth, dull, sometimes shiny, bearing several to many punctures (none in *azteca*) (30×). Pygidial plate plane to convex, not abruptly sunken medioapically as in *Calliopsis s.s.* (37) Sterna brown to testaceous. Sternum 5 produced posteriorly into a blunt, rounded, often club-like projection. Sternum 6 with a broadly concave, median bilobed portion, each lobe flattened from base to apex or apex bent abruptly ventrad to produce a pair of ventral

"prongs" usually tilted slightly towards each other. Sternum 8 with a long, median projection drawn gradually or abruptly into a terminal club. (38) Sterna and genitalia as illustrated (Figs. 58-122).

CALLIOPSIS (CALLIOPSIMA) ROZENI Shinn

(Figs. 58-62; Map 5)

Calliopsis rozeni Shinn, 1965, Amer. Mus. Novitates, 2211:2.

This species is named for Dr. Jerome G. Rozen, Jr., who has lent numerous specimens for my study of the genus. The species is closest to *C. coloradensis* and *C. kucalumea*. Superficially, it bears a striking resemblance to *C. crypta*. The male of *rozeni* has the tips of the projections beside the apical portion of metasomal sternum 6 flat, whereas in *coloradensis, kucalumea,* and *crypta* they are bent ventrad. The female of *rozeni* is distinguished from *crypta* by the fine head punctures described in (10) below and by the possession of fulvous long hairs on the scutum and scutellum, whereas in *crypta* the head punctures are coarse and the long hairs on the scutum and scutellum are brown. The female of *coloradensis* has fine, dense punctures, regularly spaced about 2 pwa on the disc of metasomal tergum 1, but those of *kucalumea* are regularly spaced less than 1 pwa, and those of *rozeni* are larger, sparse, irregularly spaced about 0.5-3 pwa.

Female. Length, 8.0 mm; forewing length, 5.5 mm; hindwing length, 3.8 mm; clypeal length, 0.60 mm; scutal length, 1.43 mm.

Head. Cream colored areas: (1) paraocular area below a sinuous line originating at middle of outer subantennal suture and extending to lower inner margin of facial fovea, thence bordering fovea ventrally, ending on orbit slightly below middle of fovea; (2) clypeus except for narrow brown apical border and two vertical bars of brown originating at dorsolateral corners of clypeal emargination, extending dorsally about five-sevenths of median length of clypeus; (3) absent on labrum; (5) subantennal plate (to all black or with irregularly shaped cream colored area); (6)absent on mandible. (7) Flagellomeres 1-4 brown and tan ventrally. (8) Hair of vertex fulvous. (10) Punctures beside lower half of frontal line large, 1-2 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.68:1.55,1.09. (14) Galea finely pebbled, galeal gap subequal to length of galea exposed beyond closed mandibles, 0.37: 0.39. (15) Head width to head length as 2.64:1.82,1.45. (17) Eye length, mio, and flagellar length as 1.39:1.55:1.39. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.48:0.48:0.41:0.36. (19) Ocellolabral equal (to subequal) to clypeal width, 1.53:1.53. (20) Clypeocellar to outer subantennal sutural as 0.92:0.82,1.12. (21) Basal labial palpomere about 2.8 times length of others combined. (22) Flagellar length about 2.0 times length of scape, 1.38: 0.68.

Mesosoma. (23) Cream colored areas: a dot on right pronotal lobe (a dot on each, or none); scutellar crest. (24) Scutal and scutellar hair fulvous, long hair concolorous with short. (25) Scutal disc with punctures about the same size as on midvertex, 0.5 pwa or less, interspaces shiny (30×). (26) Dorsal enclosure of propodeum somewhat declivous with sharp, carinate posterior border, enclosure with longitudinally vermiform ridges medially, straighter longitudinal ridges laterad. (27) Legs with light color the same as on face. Foreleg with cream color on apex of femur and knee of tibia and adjacent area subequal to it. (28) Spur with many short hairs, finely pectinate (to no distinct teeth); spur length less than half of length of middle basitarsus, 0.44:0.94. (30) Tegula transparent testaceous. Humeral plate with cream-colored apex. (31) Stigma tan. (32) Marginal cell 6-9 longer than, and 3-4 shorter than (to equal to) 9-wt, 1.17:0.99:1.02.

Metasoma. (34) Suberect hairs of discs of terga 4-5 white. (35) Tergum 1 with punctures of median area smaller than on scutum, deep, irregularly spaced, sparse medially, dense laterally, less than 1 pwa.

Male. Length, 6.5 mm; forewing length, 4.7 mm; hind wing length, 3.2 mm; clypeal length, 0.55 mm; scutal length, 1.27 mm.

Head. Yellow areas: (1) paraocular area below diagonal line originating at upper rim of antennal socket to lower margin of facial fovea ending on orbit about third of eye length below summit of eye; (6) mandible basal half to two-thirds; (7) scape with broad lateroventral stripe; a mere dot on lateroventral surface of flagellomere 1. (10) Punctures beside lower half of frontal line large, 1-2 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.53: 1.14,1.34. (14) As in female but galeal gap slightly more than half of length of galea exposed beyond closed mandibles (0.26:0.44). (15) Head width to head length as 2.35:1.70,1.38. (17)) Eye length, mio, and flagellar length as 1.31:1.14:1.53. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.43:0.41:0.29:0.32. (19) Ocellolabral greater than clypeal width, 1:41:1.26, 1.12. (20) Clypeocellar to outer subantennal sutural as 0.82:0.71,1.14. (21) Basal labial palpomere about 2.6 times length of others combined. (22) Flagellar length about 3.0 times length of scape, 1.55:0.51.

Mesosoma. (24) Scutal and scutellar hair pale grey (to pale fulvous), otherwise as in female. (25) Scutal disc with punctures slightly larger than on midvertex, 0.5-1 pwa, interspaces shiny (30×). (27) Foreleg with yellow on dorsoapical third of femur, anterior surface of tibia, basitarsus and second tarsomere entirely; third to fifth tarsomeres successively darker, testaceous to light brown; posterior surface of tibia brown. (28) Middle leg colored like foreleg but yellow on dorsoapical fifth of femur; lengths of tibia, basitarsus, and apicotarsus as 1.09:0.87:1.00. (29) Hind leg colored like middle leg, narrow brown margin may occur on anterior surface of basitarsus, apicotarsus

brown. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 0.99:0.83: 0.92.

Metasoma. (34) Suberect hairs of discs of terga 4-5 fulvous. (35) Tergum 1 with punctures of median area larger than in female, smaller than on scutum, deep, fairly regularly spaced, less than 1 pwa, interspaces shiny.

TYPE MATERIAL. Holotype male, from Rodeo, Hidalgo County, New Mexico, August 22, 1962 (J. G. Rozen, M. Statham, S. J. Hessel) on *Heterotheca subaxillaris,* and allotype female, from Portal (5 mi. W.), S. W. R. S., Cochise Co., Arizona, 5400 ft., Aug. 10, 1956 (Ellen Ordway), on *Melilotus alba,* are at the American Museum of Natural History.

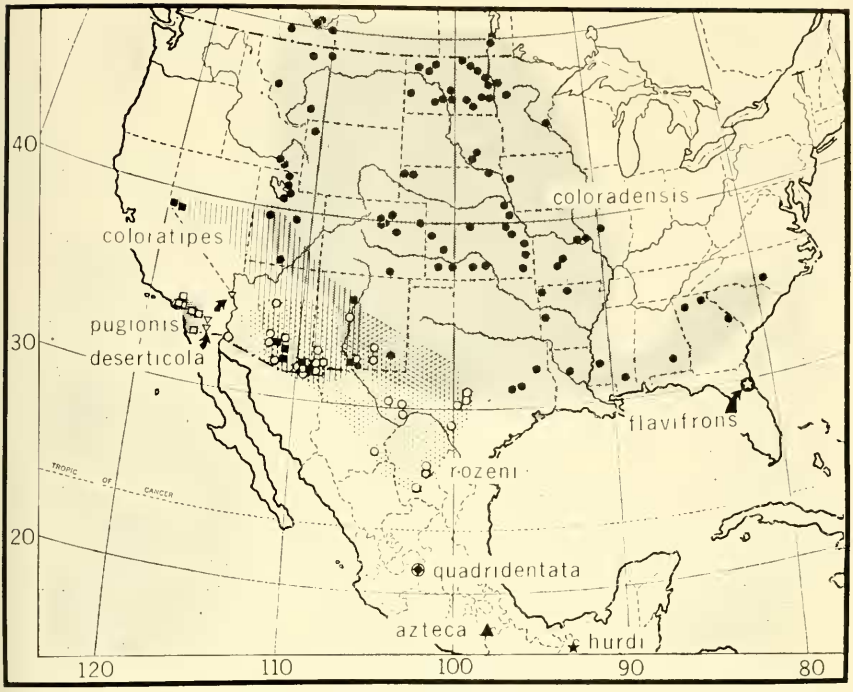
In addition, 154 male and 120 female paratypes are from the following localities: ARIZONA: Apache and vicinity; Skeleton Canyon, Benson, Bisbee, Portal and vicinity, all in Cochise Co.; Flagstaff; Mt. View; Phoenix; Santa Rita Mountains; San Xavier Mission; Superior, Pinal Co.; Tucson; Warren; Yuma: Yuma Test Station. NEW MEXICO: Granite Pass, Peloncillo Mts., Hidalgo Co.; High Rolls, Otero Co.; Lordsburg; Filmore Canyon and Soledad, Organ Mountains; Road Forks, Hidalgo Co.; Rodeo and vicinity, Hidalgo Co.; Roswell; Socorro. TEXAS: Coopers Store, Big Bend National Park, Brewster Co.; Davis Mts., Jeff Davis Co.; Marathon (20 mi. S.); Stonewall; Uvalde. CHIHUAHUA: Salaices. COAHUILA: La Gloria, south of Monclova, 3300 ft.; Paila, 3900 ft.; Piedras Negras (192 km. S.), 1300 ft.

DISTRIBUTION. The southwestern United States and north central Mexico. In addition to the type material, 4 females have been examined from 5 miles west of Junction, Kimble Co., Texas, April 15, 1961 (Rozen and Schrammel).

This species is active in April, May, June, July, August, September, and October.

GEOGRAPHIC VARIATION. Three characters are conspicuously variable in female *rozeni:* 1) the amount of yellow color on the pronotal lobe, 2) the amount of yellow on the subantennal plate, and 3) the density of the punctures of the median area of metasomal tergum 1. The first two do not appear to be clinal, but the third may be so. Specimens from Texas exhibit denser punctation than more western ones, and females from Junction, Texas, have been excluded from the type series primarily for this reason since no males were collected to confirm the determination.

DISCUSSION. It is unusual for two solitary bees of different species to be taken *in copulo,* and this has almost always been interpreted to mean that the two specimens are not, indeed, different species. One male of *rozeni* was collected *in copulo* with a female of *crypta* by J. G. Rozen (Portal, S. W. R. S., Arizona, September 14, 1962, on *Heterotheca subaxillaris*), and one pair of *rozeni* was taken *in copulo* by G. I. Stage, Rodeo (2.5 miles north), New Mexico, September 7, 1959, on *Baileya pleniradiata.* Both collectors had observed the specimens carefully prior to collection. Inasmuch as I have an interspecific mating pair of *Calliopsis chlorops* with *Calliopsis coloradensis,* I believe the phenomenon may be more common than preserved specimens indicate. Nevertheless, I have not yet seen a specimen of either sex of any of these species which can be considered an intermediate, or hybrid, form. It is



Map 5. Map showing the known distributions of *Calliopsis (Calliopsima) coloradensis* Cresson, *C. (C.) coloratipes* Cockerell, *C. (C.) pugionis* Cockerell, *C. (C.) deserticola* Shinn, *C. (C.) rozeni* Shinn, *C. (C.) quadridentata* Shinn, *C. (C.) azteca* Shinn, and *C. (C.) hurdi* Shinn. The presumptive collection locality for *Calliopsis flavifrons* Smith is also shown.

possible that the males can be deceived by some of the females of these closely related and superficially indistinguishable pairs of species. I conclude that no viable offspring are produced.

Flower Records. *Baccharis, Baileya pleniradiata, Chamaesaracha conloides, Eriocarpum gracile, Eriogonum, Gaillardia, Helianthus, Heterotheca subaxillaris, Hymenoxys odorata, Melilotus alba, Parkinsonia, Pectis papposa, Psilostrophe cooperi, Sphaeralcea emoryi?, Verbesina exauria.* Taken primarily on *Heterotheca subaxillaris* which is a favorite flower among its relatives also.

CALLIOPSIS (CALLIOPSIMA) COLORADENSIS Cresson

(Figs. 63-66; Map 5)

Calliopsis coloradensis Cresson, 1878, Trans. Amer. Ent. Soc., 7:63, female, male; Patton, 1879, Bull. U.S. Geol. Survey, 5:366; Cockerell, 1897, Canad. Ent., 29:290; 1897, Bull. Univ. New Mexico, 24:19; 1897, Proc. Acad. Nat. Sci. Phila., 49:350; 1898, Trans. Amer. Ent. Soc., 25:196, 1898, Bull. Sci. Labs. Denison Univ., 11:52; 1898, Zoologist, (4) 2:313; 1899, Ent. News, 10:4; Bridwell, 1899, Trans. Kans. Acad. Sci., 16:210; Cockerell, 1901, Ann. Mag. Nat. Hist., (7) 7:128; Cockerell and Atkins, 1902, Ann. Mag. Nat. Hist., (7) 10:44; Cock-

erell, 1906. Trans. Amer. Ent. Soc., 32:299; 1906, Bull. Amer. Mus. Nat. Hist., 22:440; Swenk and Cockerell, 1907, Ent. News, 18:178; 1908, Canad. Ent., 40:147-148; Crawford, 1912, Canad. Ent., 49:359; Robertson, 1914, Ent. News, 25:70; Cresson, 1916, Mem. Amer. Ent. Soc., 1:115; Stevens, 1919, Canad. Ent., 51:210; Cockerell, 1919. Jour. N.Y. Ent. Soc., 27:299; 1921, Amer. Mus. Nov., 24:13; Robertson, 1922, Psyche 29(4):169; Robertson, 1926, Ecology. 7:379 (anthecology); Hicks, 1926, Univ. Colo. Studies, 15:223; Robertson, 1928, Flowers and Insects, p. 10+ (anthecology); 1929, Psyche, 36(2):115 (anthecology); Stevens, 1950, North Dakota Agric. Exp. Sta. Bimon. Bull., 12:90,93 (biol.); Rozen, 1951, Jour. Kans. Ent. Soc., 24(4):142+(male genitalia); Linsley, 1958, Hilgardia, 27:561; Mitchell, 1960, North Carolina Agric. Exp. Sta. Tech. Bull. No. 141:288-289, 291-294.

coloradensis coloratipes; Pierce, 1904, Stud. Univ. Nebraska, 4:23. (misidentification)

coloratipes fedorensis; Cockerell, 1909, Ann. Mag. Nat. Hist. (8) 4:28. (misidentification)

coloradensis fedorensis; Cockerell, 1921, Amer. Mus. Novitates, 24:14.

C. sp.?, Michener, 1947, Amer. Midl. Nat., 38:447.

The species is closest to *rozeni* and *coloratipes.* It is separated in the male from them by the long ventral prongs on sternum 6, by having the volsella much expanded, and by having the punctures of tergum 1 much smaller than in *rozeni* and larger than in *coloratipes.* It is separated in the female from *coloratipes* by the dark mandibular base, from *rozeni* by the much finer punctures of tergum 1, and from both species by the regularly distributed punctures of tergum 1, which are sparse medially in them.

Female. Length, 8.8 mm; forewing length, 5.8 mm; hindwing length, 4.1 mm; clypeal length, 0.62 mm; scutal length, 1.60 mm.

Head. Cream colored areas: (1) as in *rozeni;* (2) clypeus with a broad T with convex crossbar bordering entire length of horizontal portion of frontoclypeal suture (to somewhat less), bottom of the T with adjacent small spot (more typically, clypeus light colored except for testaceous apical border and wide, twin, vertical bars of brown arising from its median portion); (3) absent on labrum; (5) subantennal plate with dot (to entirely); (6) absent on mandible. (7) As in *rozeni.* (8) Hair of vertex fulvous. (10) Punctures beside lower half of frontal line slightly smaller than in *rozeni,* 1-2 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.82:1.70,1.07. (14) Galea finely pebbled, dull, galeal gap about half length of galea exposed beyond closed mandibles, (0.31:0.58). (15) Head width to head length as 2.77:1:89, 1.47. (17) Eye length, mio, and flagellar length as 1.46:1.70:1.48. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.51:0.51:0.48:0.43. (19) Ocellolabral slightly greater than clypeal width, 1.62:1.56,1.03. (20) Clypeocellar to outer subantennal sutural as 0.99:0.87,1.14. (21) Basal labial palpomere about 2.5 times length of others combined. (22) Flagellar length about 2.1 times length of scape, 1.48:0.71.

Mesosoma. (23) Yellowish areas: apex of pronotal lobe, scutellar crest. (24) As in *rozeni,* except hairs longer. (25) Scutal disc with punctures slightly larger than those of vertex, 1 pwa or less. (26) As in *rozeni* except ridges narrower, more abundant, shinier. (27) Foreleg with yellow at apex of femur and knee of tibia. (28) Spur exceedingly finely pectinate on apical half, bearing about 10 short teeth, barely distinguishable (30×); spur length about

half of length of middle basitarsus, 0.48:0.94. (30) Tegula transparent, light amber. Humeral plate with anterior half yellow. (31) Wing clear (to faintly smoky apically, not so smoky as in *rozeni*). Stigma tan. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 1.33:0.90:1.14.

Metasoma. (34) As in *rozeni* but hairs longer. (35) Tergum 1 with punctures of median area slightly finer than on scutum, fairly regularly spaced, 2-3 pwa.

Male. Length, 6.3 mm; forewing length, 4.9 mm; hindwing length, 3.52 mm; clypeal length, 0.58 mm; scutal length, 1.41 mm.

Head. Yellow areas: (1) paraocular area below diagonal line originating at upper end (or between upper end and middle) of outer subantennal suture and extending tangent to facial fovea ending on orbit below midlevel of fovea, angle of upper corner about 40° (or 10°); (4) supraclypeal area in some cases with black border between frontoclypeal suture and yellow supraclypeal area; (5) subantennal plate, sometimes reduced to basal spot; (6) mandible basal half; (7) scape with ventral surface yellow except dark brown mesally and apically (through various states of reduction of yellow to all brown scape); yellowish ventral dots on flagellomeres 1-2 (sometimes absent). (10) As in female. (13) Orbital convergence ratio as 1.60:1.22,1.30. (14) As in female. (15) Head width to head length as 2.41:1:70,1.42. (17) Eye length, mio, and flagellar length as 1.33:1.22:1.51. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.46:0.46:0.31:0.36. (19) Ocellolabral greater than clypeal width, 1.43:1.26,1.13. (20) Clypeocellar to outer subantennal sutural as 0.85:0.68,1.25. (21) Basal labial palpomere about 2.0 times length of others combined. (22) Flagellar length about 2.9 times length of scape, 1.51: 0.53.

Mesosoma. (25) Scutal disc with punctures slightly larger than in *rozeni*, 0.5-1 pwa, interspaces shiny. (27) Foreleg with yellow on dorsoapical half (or less) of femur, tibia, basitarsus and second tarsomere, remaining tarsomeres tinged testaceous. (28) Middle leg colored like foreleg but less yellow on femur, brown patch on posterior surface of tibia (sometimes); lengths of tibia, basitarsus, and apicotarsus 1.04:0.94:0.99. (29) Hind leg colored like middle leg. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 1.12: 0.87:0.99.

Metasoma. (35) Tergum 1 with punctures of median area slightly smaller than on scutum, deep, crowded medially, contiguous, interspaces shiny.

Type Material. Lectotype female, 1 female and 2 male paratypes, Colorado (Ridings and Morrison), with no further label data, are at the Academy of Natural Sciences of Philadelphia, Types 2187, 2187.2, 2187.4, and 2187.5, respectively. Paratype 2187.3, same data, is a female specimen of *C. chlorops*. I suggest that the indefinite type locality be restricted to the Colorado counties of Denver, northern half of Jefferson, and eastern half of Boulder, where

specimens taken agree exactly with the types. The description of the male is principally based on paratype No. 2187.2.

DISTRIBUTION. Alberta to southern Utah and southern New Mexico, east to the Mississippi River, thence through eastern Texas and the Gulf States to the east slope of the Appalachian Mountains in North Carolina. Not yet found in Florida, although it has likely occurred there in the past (cf. remarks regarding *Calliopsis flavifrons* Smith under the following section, Geographic variation). It is a late summer-early autumn bee collected between June 27, 1918, at Winnfield, Louisiana, and Oct. 10, 1961, at Nacogdoches, Texas, but most records are in July and August.

In addition to the type specimens, about 490 others have been studied from the following localities: ALBERTA: Lethbridge; Medicine Hat; Scandia; Tilley. MANITOBA: Balmoral; Stony Mountain; Stormy Mountain; Winnipeg. ALABAMA: Pickett Springs, Montgomery Co. ARKANSAS: Chessman Ferry, Stone Co.; Fayetteville, Washington Co.; Polk Co. COLORADO: Boulder; Denver; Hoehne; Limon; Loveland; Roggen; Wray. GEORGIA: Augusta, Richmond Co.; Cartersville, Bartow Co.; Nacoochee Valley. IDAHO: Downey; Fort Hall. ILLINOIS: Carlinville. IOWA: Sioux City. KANSAS: Blue Rapids; Dodge City (8 mi. N.E.); Douglas Co.; Garnett; Hutchinson; Lakin (4 mi. E.); Riley Co.; Scott Co., 2970 ft.; Sherman Co., 3690 ft.; Smith Co., 1800 ft.; Stafford Co.; Yates Center. LOUISIANA: Winnfield, Winn Co. MINNESOTA: Detroit; Moorhead; Powder Plant Woods, Ramsey Co.; University Farms, Ramsey Co. MISSISSIPPI: Hattiesburg; Utica. MISSOURI: Conway (10 mi. N.); Gilmore; High Hill; Lebanon (12 mi. E.). MONTANA: Bozeman; Hill Co.; Missoula; Pompey's Pillar, Yellowstone Co.; Pondera Co. NEBRASKA: Crofton (2 mi. W.; 7 mi. N.W.); Gordan, Sheridon Co.; Harrison (13 mi. N.); Lincoln; West Point. NEW MEXICO: Organ Mountains, Filmore Canyon, Dona Ana Co., 5400 ft.; Roswell (5 mi. E.), Chaves Co. NORTH CAROLINA: Aberdeen, Moore Co. NORTH DAKOTA: Beach, Bismarck; Carpio; Crary; Devils Lake; Edgeley; Fargo; Glen Ullin (10 mi. E); Grand Forks; Granville; Hatton; Jamestown; Lakota; McKenzie; Mandan; Minot; Mott; Perth; Sentinel Butte; Valley City; Williston. SOUTH DAKOTA: Geddes (5 mi. E.); Fort Thompson. TEXAS: Brazos Co.; Fedor; Lee Co.; Nacogdoches. UTAH: Farr West; Garfield; Knaub; Magna; Petersboro; Price; Topaz; Williard. WYOMING: Waltman, Natrona Co.; Yellowstone National Park.

GEOGRAPHIC VARIATION. This species is more variable than any other species of *Calliopsima*. The subgenus as a whole consists of rather more closely related species than does either *Calliopsis s.s.* or *Perissander*. It is about the same in this respect as *Verbenapis* whose species are possibly even more closely related than those in *Calliopsima*.

The most obvious variation is in size. The size grades from the large robust specimens of Canada and the Rocky Mountain States to the small specimens from the Missouri and Mississippi River valleys from Missouri to Mississippi.

Seven characteristics were investigated for use as total size indicators because of the high variability of total length. These characteristics were measured for 33 male specimens from all parts of the range of the species and the correlations were calculated among them with the results shown in Table 2.

These results suggest that scutal length, clypeal length, and flagellar length are most highly correlated with all the other variables, and that eye length has the smallest correlation with all the others.

Based upon these data and similar ones for *C. andreniformis*, wing length,

Table 2. Correlation Coefficients of Characteristics for Expressing Total Size of a Bee Based on *Calliopsis coloradensis*

	Hindwing Length	Scutal Length	Head Length	Clypeo-cellar	Clypeal Length	Eye Length	Flagellar Length
Hindwing Length	1.000	.884	.817	.870	.900	.639	.864
Scutal Length		1.000	.883	.888	.948	.693	.935
Head Length			1.000	.779	.888	.637	.830
Clypeo-cellar				1.000	.863	.657	.838
Clypeal Length					1.000	.653	.931
Eye Length						1.000	.639
Flagellar Length							1.000
Multiple Correlation of each variable with all the others	.92	.97	.90	.91	.97	.70	.95

scutal length, and clypeal length were chosen as suitable measures of the total size of a bee. These are the introductory measurements given for each species treated in this genus.

A summary of the salient differences between male topotypical specimens of *coloradensis* and those of the Missouri and Mississippi River basins is given in Table 2. The measurements are for the male allotype from Colorado, and for a Missouri River specimen from Gilmore, Missouri. The latter is representative of the specimens from the two river systems and from the southeastern United States. I do not feel that there is an adequate basis to consider these latter specimens as a species separate from *coloradensis*. I would like to see more specimens and comparative ecological data before reaching a decision on their status. If they eventually are shown to be a distinct species there is every reason to use the available name *Calliopsis flavifrons* Smith, 1853. Smith's description of the *flavifrons* collected in East Florida would fit only this form of *Calliopsis* which is the only representative of its subgenus in the southeastern United States. Specimens from localities between Colorado and the Mississippi are somewhat variable with respect to the characters given below. However, no clear clinal changes have been uncovered although the average size of males increases steadily from Missouri to Colorado and from North Carolina to Texas. The typical southeastern male is only slightly more than three-fourths the length of the typical Colorado male.

TABLE 3. Comparison of Rocky Mountain forms of *C. coloradensis* with forms from the southeastern United States

Character	Colorado	Missouri
Hind wing length	1.17	0.97
Head length	1.70	1.36
Inner subantennal sutural/galeal gap	>1	≦1
Galeal length/clypeocellar	>1	≦1
Basal labial palpomere length/clypeocellar	≧1	<1
Eye length/scutal length	<1 (1.33:1.41)	≅1 (1.02:1.04)
Eye profile width/antennocellar	≦1 (0.71:0.73)	>1 (0.61:0.53)
Eye profile width/outer subantennal sutural	>1 (0.73:0.68)	<1 (0.53:0.56)
Midocellar interocular/flagellar length	>1 (1.60:1.51)	<1 (1.26:1.34)
Fore basitarsal length/clypeocellar	<1 (0.85:0.94)	<1 (0.68:0.71)
Dorsal propodeal enclosure, hind border of median portion	Weakly carinate	Rolled anteriad, or obscurely carinate
Punctures of frons	Finer	Coarser
Hind tibia, posterior surface	Mostly yellow	Mostly brown
Outline of vertex in facial aspect	Flat	Arched
Penis valve length/volsella length	Greater	Lesser
Apodemes of penis valves	Shorter	Longer

FLOWER RECORDS. *Anthemis cotula, Aplopappus pluriflorus, Aster dumosus, A. praetus, Bidens laevis, B. aristosa, Boltonia asteroides, Chrysopsis, Chrysothamnus nauseosus, Coreopsis tripteris, Eriocarpum gracile, Grindelia perennis, G. squarrosa, Helenium nudiflorum, Heterotheca subaxillaris, Macrotera, Rudbeckia triloba, Silphium, Solidago rigida, S. serotina.*

Robertson (1922) studied the anthecology of this species at Carlinville, Illinois. His results are given below:

FEMALES COLLECTING POLLEN	MALES SUCKING NECTAR	MALE-FEMALE IN COPULO
Astereae:		
Boltonia asteroides	*Boltonia asteroides*	*Boltonia asteroides*
Solidago canadensis	*Solidago canadensis*	*Solidago canadensis*
Heliantheae:		
Bidens aristosa	*Bidens aristosa*	*Bidens aristosa*
Rudbeckia triloba	*Rudbeckia triloba*	
Coreopsis tripteris		

CALLIOPSIS (CALLIOPSIMA) PECTIDIS Shinn

(Figs. 67-71; Map 6)

Calliopsis pectidis Shinn, 1965, Amer. Mus. Novitates, 2211:10.

This species is named for one of the genera of plants, *Pectis,* used as its food source, and is adopted from the manuscript name proposed for it by

Prof. P. H. Timberlake who recognized it as a new form more than a decade ago. The closest relatives are *C. timberlakei* and *C. bernardinensis.* All three species comprise a closely related group which has close affinities with *rozeni.*

The male is separated from other species of *Calliopsima* by the yellow scape with light brown apical rim and by the shape of the ventral protuberance of the apical portion of the penis valve (Fig. 71). The female is distinguished by the presence of large amounts of cream coloration on the tibiae and basitarsi as described in (27), (28), and (29) below, and by the characteristic nap-like vestiture of the scutum as described in (24) below.

Female. Length, 7.7 mm; forewing length, 5.0 mm; hindwing length, 3.4 mm; clypeal length, 0.56 mm; scutal length, 1.49 mm.

Head. Cream colored areas: (1) paraocular area as described for subgenus, sinuous line originating at a point about two-thirds up outer subantennal suture and ending on orbit at about level of middle of fovea; (2) as in *rozeni* except brown clypeal bars narrower, extending dorsally about five-eighths (or less) of median length of clypeus; (3) labrum except for testaceous rim of labral plate and median area apical to it; (5) subantennal plate; (6) mandible about basal fourth; (7) scape with small apicoventral dot, base testaceous ventrally; pedicel and flagellum as in *rozeni* except lighter brown. (8) Hair color as in *rozeni* but all areas with shorter, more plumose hair. (10) Punctures beside lower half of frontal line larger than in *rozeni,* 1-2 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.60:1.51,1.05. (14) Galea shinier, more finely pebbled than in *rozeni.* (15) Head width to head length as 2.58:1.79,1.45. (17) Eye length, mio, and flagellar length as 1.36:1.51:1.45. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.53:0.43: 0.41:0.37. (19) Ocellolabral greater than (to subequal to) clypeal width, 1.48:1.45,1.02. (20) Clypeocellar to outer subantennal sutural as 0.90:0.75,1.20. (21) N. A., measured on paratype of equivalent size: basal labial palpomere about 2.3 times length of others combined. (22) Flagellar length 2.1 times length of scape, 1.45:0.68.

Mesosoma. (23) Cream colored areas: apex of pronotal lobe, scutellar crest. (24) Hair about half length of that of *rozeni,* more plumose. Scutal and scutellar hair color as in *crypta* except long dark hairs of lighter brown hue; short hairs dense, profusely branched concealing scutal punctures, appearing like a closely applied nap at 10×, highly distinctive, unique in its group. (25) Scutal disc with punctures contiguous, smaller than in *rozeni.* (26) As in *rozeni* but enclosure shorter. (27) Foreleg with cream color at apex of femur, most of anterior and posterior surfaces of tibia dorsally, and basal half of anterior surface of basitarsus. (28) Spur length half of length of middle basitarsus, 0.41:0.82. (29) Hind leg colored like foreleg but anterior surface of basitarsus entirely light with brown rim. (30) Tegula hyaline laterally, straw

color posteriorly. Humeral plate as in *rozeni*. (31) As in *rozeni*. (32) Marginal cell 6-9 less than (to subequal to), and 3-4 shorter than 9-wt, 0.92:0.82:0.95.

Metasoma. (34) Tergal hair bands denser than in *rozeni*, more plumose, hence much more distinct. Suberect hairs of discs of terga 4-5 brownish (almost always whitish). (35) As in *rozeni* but much smaller, regularly spaced, less than 1 pwa.

MALE. Length, 7.2 mm; forewing length, 4.3 mm; hindwing length, 2.9 mm; clypeal length, 0.56 mm; scutal length, 1.37 mm.

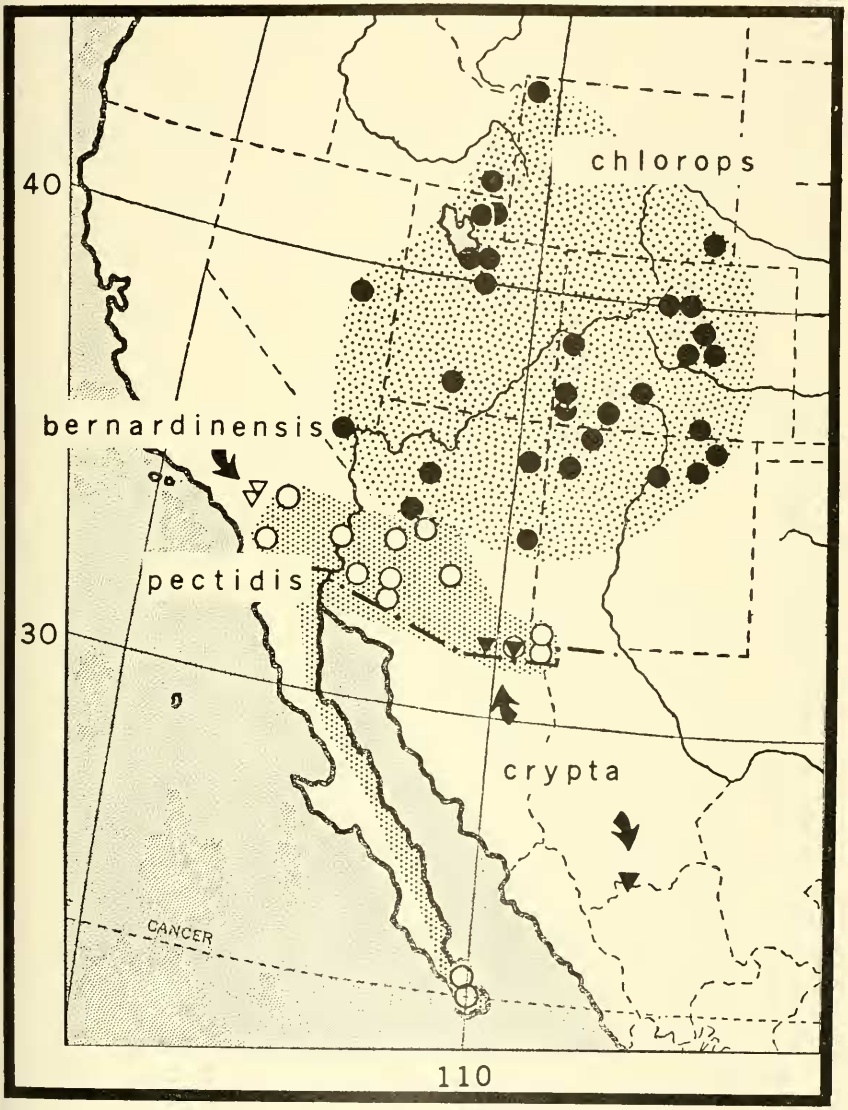
Head. Yellow areas: (1) paraocular area below a dorsally convex line originating at upper rim of antennal socket and extending to lower inner margin of facial fovea ending on orbit at about level of lower margin of fovea; (6) as in *rozeni;* (7) scape entirely (or with a longitudinal streak of brown on dorsal surface); pedicel and flagellomere 1 on ventrolateral surfaces. (10) As in *rozeni*. (13) Orbital convergence ratio as 1.46:1.14,1.28. (14) As in female. (15) Head width to head length as in *rozeni*, 2.35:1.70,1.38. (17) Eye length, mio, and flagellar length as 1.22:1.14:1.62. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.41:0.43:0.28:0.32. (19) Ocellolabral greater than clypeal width, 1.38:1.14,1.21. (20) Clypeocellar to outer subantennal sutural as 0.80:0.68,1.18. (21) N. A., taken on paratype of equivalent size: basal labial palpomere about 1.6 times length of others combined. (22) Flagellar length about 3.3 times length of scape, 1.62:0.49.

Mesosoma. (25) As in *rozeni* but smaller, less than half pwa, interspaces shiny. (27) Foreleg with coxa yellow on apical half of ventral surface, trochanter with yellow patch apicoventrally, femur with yellow on apical three-fourths of anterodorsal surface and apical third of posterior surface, tibia and tarsomeres 1-4 yellow, tarsomere 5 testaceous. (28) Middle leg with coxal yellow reduced to apical fourth of ventral surface, trochanter with apicoventral yellow patch smaller than that of foreleg, femur and tibia with yellow pattern similar to that of foreleg, tarsomeres 1-3 yellow, tarsomeres 4-5 successively darker testaceous; lengths of tibia, basitarsus, and apicotarsus as 0.95:0.90:0.95. (29) Hind leg with yellow color pattern of trochanter, femur, and tibia similar to those of middle leg; coxa with yellow as on front trochanter; tarsomeres 1-2 yellow, tarsomeres 3-5 successively darker testaceous. (32) Marginal cell 6-9 equal to (to subequal to), and 3-4 shorter than 9-wt, 0.87:0.78:0.87.

Metasoma. (34) As in female but very few erect, brownish hairs. (35) Tergum 1 with punctures of median area smaller than on scutum or in *rozeni*, regularly spaced, contiguous, interspaces shiny.

TYPE MATERIAL. Holotype male and allotype female, from Portal (2 miles N.E.), Cochise Co., Arizona, August 21, 1962 (J. G. Rozen, M. Statham, S. J. Hessel), are at the American Museum of Natural History.

In addition 65 males and 47 female paratypes are from the following localities: Arizona: Ajo; Aguila; Brenda (2 mi. W.), Yuma Co.; Congress (4 mi. S.W.); Florence Junction (3.1 mi. S.), Pinal Co.; Gila Bend and 28 mi. E., Maricopa Co.; Portal and vicinity, Cochise Co.; Salome (2.3 mi. N.). California: Blythe (10 mi. N.); Julian (12 mi. E.); San Diego Co.; Twentynine Palms. New Mexico: Carrizozo, Lincoln Co. ; Lordsburg (11 mi. N.W.); Road Forks; Rodeo. Baja California Sur: San Pedro; Sierra de la Laguna Mountains, Big Canyon (about latitude 23° 34′ N., longitude 110° 00′ W.).



Map 6. Map showing the known distributions of *Calliopsis (Calliopsima) chlorops* Cockerell, *C. (C.) bernardinensis* Michener, *C. (C.) pectidis* Shinn, and *C. (C.) crypta* Shinn.

Discussion and Distribution. Dr. Paul D. Hurd, Jr., has informed me (in litt.) that two female *Holcopasites arizonicus* (Linsley) were taken in association with a female *C. pectidis* by Dr. Mont A. Cazier, 2 mi. N.E. of Portal, Arizona, Sept. 24, 1961. This is the second species record of a *Calliopsis-Holcopasites* association, the other being of *H. calliopsidis* (Linsley) with *C. andreniformis* Smith. *C. pectidis* is apparently widespread from southern New Mexico to the Mohave and Colorado Deserts in California and south to near the tip of Baja California. I anticipate its discovery in the Sonoran Desert of northern Mexico. The species is active from August to October.

Flower Records. *Aplopappus, Baccharis, Baileya pleniradiata, Helianthus, Heterotheca subaxillaris, Hymenothrix wislizeni, Melilotus alba, Pectis angustifolia, P. papposa, Tidestromia lanuginosa, Verbesina encelioides.* Seven of the same genera and four of the same species are visited by *pectidis* and *rozeni.*

CALLIOPSIS (CALLIOPSIMA) TIMBERLAKEI, new species

(Figs. 72-76; Map 7)

The specific name is given to honor Mr. P. H. Timberlake, Associate Entomologist, Emeritus, of the University of California, Riverside, who lent me his entire collection of *Calliopsis* including several new, unpublished species he had earlier recognized.

Calliopsis timberlakei is closest to *pectidis.* It is separated in the male by the sparser, longer, scutal hair which does not conceal the scutal punctation, and by the partially yellow pedicel. The female is distinguished by the entirely yellow clypeus which lacks brown clypeal bars.

Female. Length, 7.7 mm; forewing length, 4.8 mm; hindwing length, 3.47 mm; clypeal length, 0.58 mm; scutal length, 1.33 mm.

Head. Yellow areas: (1) paraocular area as described for subgenus, sinuous line originating near upper end of subantennal suture; (2) clypeus except for brown markings near anterior tentorial pit, black subtriangular area with anterior tentorial pit as center, and testaceous apical border; (3) labrum except brown spot medioapically beyond labral plate (sometimes along apical border of labral plate); (5) subantennal plate; (6) mandible basal half; (7) scape a tiny area on extreme dorsolateral surface and at base, flagellomeres 1-4 tan ventrally. (8) Hair of vertex fulvous. (10) Punctures beside lower half of frontal line slightly smaller than in *coloradensis,* 1-4 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.56:1.48,1.06. (14) Galea finely pebbled, shiny basally, dull apically. (15) Head width to head length as 2.47:1.72,1.44. (17) Eye length, mio, and flagellar length as 1.34:1.48:1.38. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.49:0.41:0.39:0.36. (19) Ocellolabral greater than clypeal width, 1.48:1.41,1.05. (20) Clypeocellar to outer

subantennal sutural as 0.90:0.77,1.18. (21) Basal labial palpomere about 2.5 times length of others combined. (22) Flagellar length about 2.2 times length of scape, 1.36:0.61.

Mesosoma. (23) Yellowish areas: apex pronotal lobe; scutellar crest. (24) Color as in *rozeni,* length of shorter hairs intermediate between *rozeni* and *coloradensis.* (25) Scutal disc with punctures finer than in *rozeni* and *bernardinensis,* 0.5-1 pwa. (26) Dorsal enclosure of propodeum as in *rozeni* except ridges more regularly spaced, slightly farther apart. (28) Foreleg with yellow at dorsal apex of femur, dorsal surface of tibia, and base (to all) of basitarsus. (28) Middle leg colored like foreleg but tibial and basitarsal yellow less extensive, not reaching apices of segments; spur length half of length of middle basitarsus, 0.43:0.85. (29) Hind leg with yellow patch on femur dorsosubapically and on tibia anterobasally. (30) Tegula testaceous. Humeral plate yellowish apically. (31) Wing not noticeably smoky to naked eye. Stigma testaceous. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 0.66:0.77:0.94.

Metasoma. (34) As in *rozeni* but hair longer and denser. (35) Tergum 1 with punctures of median area smaller than on scutum, deep, fairly regularly spaced, 1-2 pwa.

Male. Length, 5.5 mm; forewing length, 4.0 mm; hindwing length, 2.80 mm; clypeal length, 0.51 mm; scutal length, 1.12 mm.

Head. Yellow areas: (1) paraocular area below diagonal line originating at upper end of outer subantennal suture and extending dorsolaterally tangent to facial fovea, ending on orbit at about midlevel of facial fovea; (6) mandible basal half; (7) scape, except for brown dorsoapical band with streak; pedicel, ventrolaterally; flagellomeres 1-3, ventrally. (10) As in female. (13) Orbital convergence ratio as 1.33:1.02,1.30. (14) As in female. (15) Head width to head length as 2.11:1.46,1.44. (17) Eye length, mio, and flagellar length as 1.17:1.02:1.43. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.41:0.37:0.27:0.34. (19) Ocellolabral greater than clypeal width, 1.28:1.11, 1.15. (20) Clypeocellar to outer subantennal sutural as 0.77:0.63,1.21. (21) Basal labial palpomere about 1.8 times length of others combined. (22) Flagellar length about 3.2 times length of scape, 1.43:0.44.

Mesosoma. (25) Scutal disc with punctures 1 pwa or less, interspaces dull. (27) Foreleg with yellow on coxa apically, femur dorsoapically, extending onto anterior and posterior surfaces, tibia (a dot of brown on posterior surface sometimes), basitarsus and mediotarsus, distitarsus testaceous. (28) Middle leg colored like foreleg but less yellow on femur and entire apicotarsus testaceous; lengths of tibia, basitarsus, and apicotarsus as 0.85:0.66:0.78. (29) Hind leg colored like middle leg. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 0.83:0.70:0.78.

Metasoma. (34) As in female. (35) Tergum 1 with punctures of median area medium sized, less than 1 pwa, interspaces shiny.

TYPE MATERIAL. Holotype male and allotype female, from Three Rivers (7.5 m. S.), Otero Co., New Mexico, Sept. 9, 1961 (P. D. Hurd), on *Gutierrezia microcephala,* are in the collections of the California Insect Survey, University of California, Berkeley.

In addition, 24 males and 37 female paratypes are from the following localities: ARIZONA: Chambers, 1 female, Sept. 19, 1938 (I. H. McCracken), *Helianthus;* Coconino Co., 1 female, Aug. 19, 1927 (P. A. Readio); Petrified Forest, 1 female, Aug. 27, 1931 (P. H. Timberlake), *Gutierrezia sarothrae;* Taylor, Navajo Co., 1 male, Sept. 14, 1961 (P. D. Hurd), *Gutierrezia;* Tucson (9 mi. S.E.), 1 female, Sept. 3, 1961 (P. D. Hurd), *Bahia absinthifolia.* NEW MEXICO: Carlsbad (5 mi. N.), Eddy Co., 1 female, Sept. 21, 1956 (J. W. MacSwain); Carrizozo, 1 male, 1 female, Sept. 10, 1961 (P. D. Hurd), *Gutierrezia microcephala; idem* (8 mi. N.), 1 male, *Aplopappus spinulosus;* Correo, 1 female, Sept. 4, 1930 (Timberlake), *Gutierrezia sarothrae;* Laguna, 2 males, Sept. 4, 1930 (Timberlake), *Isocoma wrighti;* Mesilla Park (8.5 mi. E.) Dona Ana Co., 1 male, Sept. 5, 1961 (P. D. Hurd), *Gutierrezia lucida;* Rinconada, 1 female, Sept. 26 (T. D. A. Cockerell, No. 5547), tall *Bigelovia;* Roswell, Chaves Co., 2 males, Sept. 11, 1961 (P. D. Hurd), *Gutierrezia longifolia;* Roswell, 3 males, 1 female, Sept. 12, 1937 (R. H. Crandall); Three Rivers (7.5 mi. S.), Otero Co., 11 males, 27 females, Sept. 9, 1961 (P. D. Hurd), *Gutierrezia microcephala.* TEXAS: The Basin, Big Bend National Park, 1 male, 1 female, *in copulo,* Oct. 4, 1956 (J. W. MacSwain). UTAH: Wildcat Canyon (N. of Beaver), 1 male, Sept. 7, 1954 (G. F. Knowlton), *Chrysothamnus nauseosus.*

DISTRIBUTION. Extreme western Texas, northwest through New Mexico to northern Arizona, the range is allopatric to that of the close relative *pectidis. C. timberlakei* occurs generally in more mountainous localities, whereas *pectidis* is more of a desert form.

FLOWER RECORDS. *Haplopappus spinulosus, Bahia absinthifolia, Bigelovia* (tall), *Chrysothamnus nauseosus, Gutierrezia longifolia, G. microcephala, G. sarothrae, Isocoma wrightii. C. timberlakei* shares one genus, *Haplopappus,* with *C. pectidis,* and one genus, *Gutierrezia,* with *bernardinensis.*

CALLIOPSIS (CALLIOPSIMA) BERNARDINENSIS Michener

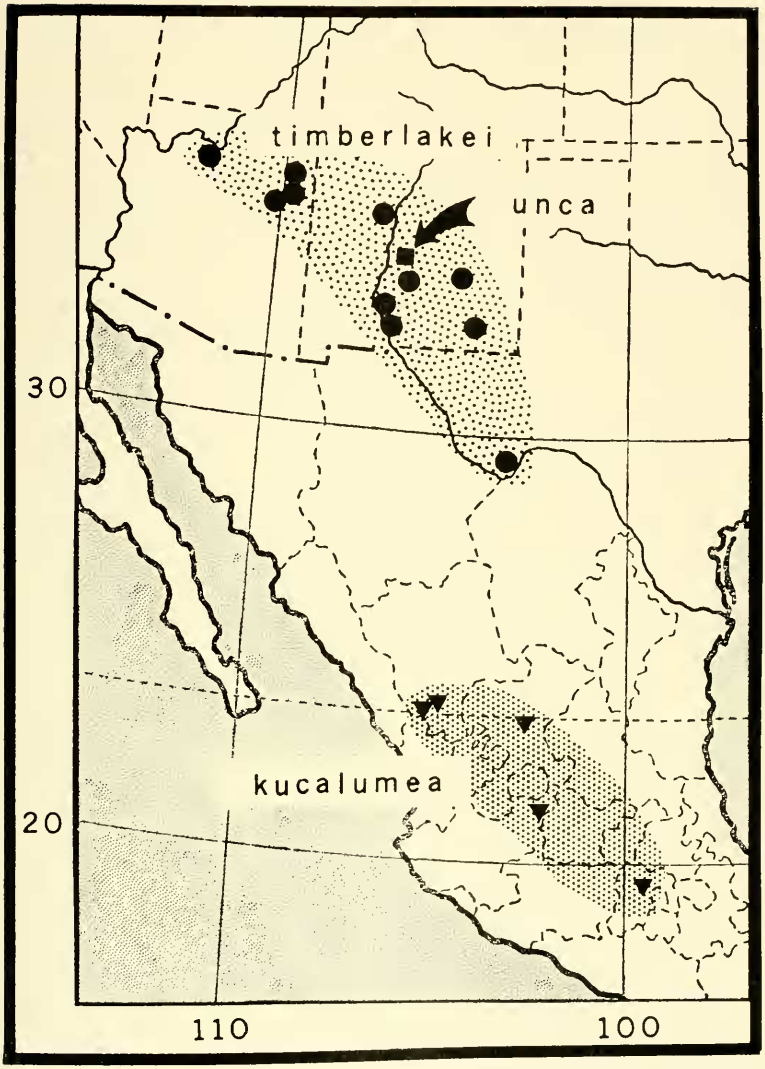
(Figs. 77-82; Map 6)

Calliopsis bernardinensis Michener, 1937, Ann. Mag. Nat. Hist., (10)19:323; Michener, 1951, *in* Muesebeck *et al.,* U.S. Dept. Agric., Monogr. No. 2:1103.

This species is closest to *timberlakei* and *pectidis.* The male is distinguished by the densely punctured, dull, tergum 1, with interspaces about 0.33 pwa, by the flagellum with posterior surface brown, and by the large patches of brown color on the posterior surfaces of the tibiae. The female is distinguished by the completely yellow labrum and the brown hind leg which sometimes bears a small yellow spot near the base of the tibia beside the basitibial plate.

FEMALE. Length, 7.6 mm; forewing length, 5.2 mm; hindwing length, 3.50 mm; clypeal length, 0.58 mm; scutal length, 1.33 mm.

Head. Yellow areas: (1) as in *timberlakei;* (2) as in *timberlakei;* (3) labrum entirely; (5,6,7,8) as in *timberlakei.* (10) Punctures beside lower half



Map 7. Map showing the known distributions of *Calliopsis (Calliopsima) timberlakei* Shinn, *C. (C.) unca* Shinn, and *C. (C.) kucalumea* Shinn.

of frontal line smaller than those of *pectidis* or *timberlakei,* 1 pwa or less, interspaces shiny. (13) Orbital convergence ratio as 1.58:1:43,1.11. (14) As in *timberlakei.* (15) Head width to head length as 2.48:1.77,1.40. (17) Eye length, mio, and flagellar length as 1.34:1.43:1.36. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.48:0.44:0.39:0.39. (19)Ocellolabral greater than clypeal width, 1.50:0.80,1.87. (20) Clypeocellar to outer suban-

tennal sutural as 0.92:0.77,1.20. (21) Basal labial palpomere about 2.5 times length of others combined. (22) Flagellar length about 2.2 times length of scape, 1.36:0.61.

Mesosoma. (23) Yellowish areas: apex pronotal lobe; scutellar crest. (24) Color as in *timberlakei,* length of shorter hairs intermediate between *pectidis* and *timberlakei;* some specimens with shorter hairs dense, profusely branched, obscuring scutal surface as in *pectidis.* (25) Scutal disc with punctures smaller than in *pectidis,* larger than in *timberlakei,* slightly more than 0.5 pwa. (26) Dorsal enclosure of propodeum as in *timberlakei* except ridges slightly further separated. (27) Foreleg with yellow on femur dorsoapically, dorsal surface of tibia, basal half or less of anterior surface of basitarsus. (28) Middle leg with yellow on femur dorsoapically, on basal half of dorsal surface of tibia, sometimes a spot on basitarsus basally; spur length about half of basitarsal length, 0.39:0.80. (29) Hind leg brown, rarely with yellow basal spot anterior to basitibial plate. (30) Tegula pale straw color to colorless. Humeral plate yellow apically. (31) As in *timberlakei.* (32) Marginal cell 6-9 longer than, and 3-4 equal to 9-wt, 1.11:0.94:0.94.

Metasoma. (34) Tergal hair bands entire although somewhat sparser medially and sparser than in *pectidis;* suberect hair of discs of terga 4-5 white. (35) Tergum 1 with punctures of median area smaller than on scutum, smaller than in *pectidis,* larger than in *timberlakei,* deep, regularly spaced, 0.5-1 pwa.

Male. Length, 6.4 mm; forewing length, 4.2 mm; hindwing length, 2.80 mm; clypeal length, 0.51 mm; scutal length, 1.10 mm.

Head. Yellow areas: (1) paraocular area as in *timberlakei;* (6) mandible basal half; (7) scape, except dorsally; pedicel, ventrolaterally, much less distinct than in *timberlakei* (absent in some cases); flagellomere 1, ventrally (sometimes). (10) Punctures beside lower half of frontal line slightly larger than in *timberlakei,* 0.5 pwa or less, interspaces shiny. (13) Orbital convergence ratio as 1.34:1.00,1.34. (14) As in female. (15) Head width to head length as 2.07:1.53,1.36. (17)) Eye length, mio, and flagellar length as 1.17: 1.00:1.50. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.39:0.37:0.22:0.32. (19) Ocellolabral greater than clypeal width, 1.28:1.11, 1.15. (20) Clypeocellar to outer subantennal sutural as 0.77:0.63,1.22. (21) Basal labial palpomere about 2.3 times length of others combined. (22) Flagellar length about 3.4 times length of scape, 1.50:0.44.

Mesosoma. (25) Scutal disc with punctures fine, slightly larger than in *timberlakei,* mostly 0.5 pwa, interspaces moderately shiny. (27) Foreleg with yellow as in *timberlakei* but sometimes absent on coxa, tibia except large posterior patch of brown reaching almost to apex. (28) Middle leg colored like foreleg but yellow absent from coxa, apicotarsus pale brown; lengths of tibia. basitarsus, and apicotarsus as 0.87:0.73:0.77. (29) Hind leg colored like mid-

dle leg, brown patch of tibia covering most of posterior surface. (32) Marginal cell 6-9 greater than, and 3-4 subequal to 9-wt, 0.87:0.78:0.80.

Metasoma. (35) Tergum 1 with punctures of median area largest, deepest of the *pectidis* group, crowded, contiguous, giving surface a definite bumpy character.

Type Material. Holotype male and allotype female, from Erwin Lake, San Bernardino Mountains, California, Aug. 22, 1932 (C. D. Michener), are at the California Academy of Science, San Francisco. I have not seen the types. The above description of the female is principally based on a paratype with the same label data as the type, while that of the male is based on a specimen from the Upper Santa Ana River, San Bernardino Co., California, Sept. 1, 1946 (Grace H. and John L. Sperry), on *Senecio ionophyllus*.

Distribution. A late-summer, early-autumn bee.

Fourteen males and eight females have been studied from the following localities, which include the type locality: California: Erwin Lake, San Bernardino Mts., Aug. 16, 22, 1932 (C. D. Michener); Riverside, Sept. 26-28, 1934 (P. H. Timberlake), on *Gutierrezia sarothrae;* Santa Ana River (upper), San Bernardino Co., Aug. 23, 1946 (Grace H. and John L. Sperry), on *Senecio ionophyllus.*

Discussion. This species is probably a form isolated from an originally continuous range of *C. timberlakei.*

Flower Records. *Gutierrezia sarothrae* and *Senecio ionophyllus,* both Compositae. *Gutierrezia* is also used by *timberlakei.*

CALLIOPSIS (CALLIOPSIMA) UNCA, new species

(Figs. 83-86; Map 7)

The specific name is from the Latin *uncus,* a hook, named for the hook-like projection on the outer posterior corner of the male volsella. It is closest to *crypta* and *chlorops* but is distinguished by the shape of the male volsella, and by the large amount of yellow on the ventral surface of the scape as described below in (7).

Male. Length, 6.8 mm; forewing length, 4.5 mm; hindwing length, 3.10 mm; clypeal length, 0.54 mm; scutal length, 1.19 mm.

Head. Yellow areas: (1) paraocular area below diagonal line originating at antennal socket above upper end of outer subantennal suture and extending concavely dorsolaterally tangent to facial fovea, ending on orbit slightly above level of lower border of facial fovea; (6) mandible basal half; (7) scape except dorsal surface and apex ventromesally; flagellomeres 1-2 both with tiny patch ventrally. (8) Hairs of vertex fulvous with dark tips, of frons and clypeus white, more plumose than in *chlorops* or in *crypta.* (10) Punctures beside lower half of frontal line larger than those of *azteca* or *chlorops,* about the same size as those of *crypta,* 1 pwa, interspaces shiny. (13) Orbital con-

vergence ratio as 1.43:1.11,1.29. (14) Galea shiny, apical pebbling barely perceptible (30×). (15) Head width to head length as 2.23:1.60,1.39. (17) Eye length, mio, and flagellar length as 1.21:1.11:1.56. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.43:0.41:0.27:0.34. (19) Ocellolabral less than clypeal width, 1.16:1.21,0.96. (20) Clypeocellar to outer subantennal sutural as 0.80:0.66,1.20. (21) Basal labial palpomere about 2.4 times length of others combined. (22) Flagellar length about 3.0 times length of scape, 1.53:0.51.

Mesosoma. (24)) Scutal and scutellar shorter hairs grayish-fulvous, longer hairs amberish, dark when viewed from behind. (25) Scutal disc with punctures deepest, most distinct in its group, relatively large, 0.33 pwa, interspaces moderately shiny. (26) Dorsal enclosure of propodeum with carinate border, shiny (30×) with high, narrow, strongly vermiform longitudinal ridges medially, somewhat straighter longitudinal ridges laterally, median portion produced posteriorly. (27) Foreleg with yellow as in *bernardinensis* but absent from coxa. (28) Middle leg with yellow on femur dorsoapically, tibia except large median brown patch on posterior surface, basitarsus and following two tarsomeres, last two testaceous; lengths of tibia, basitarsus, and apicotarsus as 1.02:0.78:0.94. (29) Hind leg colored like middle leg but tibia with only tiny, pale brown patch medially. (30) Tegula transparent light brown with anterior yellow patch. Humeral plate yellow apically. (32) Marginal cell 6-9 and 3-4 both less than 9-wt, 0.88:0.78:0.94.

Metasoma. (34) Tergal hair bands indistinct, hairs fine, appressed, whitish. Suberect hairs of discs of terga 5-6 white. (35) Tergum 1 with punctures of median area smaller than on scutum, deep, distinct, about 0.33 pwa, interspaces moderately shiny.

Type Material. Holotype male, from Bingham (3 mi. W.), Socorro Co., New Mexico, Sept. 12, 1961 (P. D. Hurd), on *Baileya pleniradiata,* is the property of the California Insect Survey, University of California, Berkeley.

Distribution. The type locality of this species is a relatively short distance from the site of the world's first atomic bomb explosion near Alamogordo, New Mexico, in July, 1945. It seems unlikely, however, that this man-made radiation has created a mutated population from which this unique specimen has arisen. Persistent collecting from central to southern New Mexico and adjacent Mexico will probably be necessary to get a good study series of specimens.

CALLIOPSIS (CALLIOPSIMA) AZTECA, new species

(Figs. 91-94, Map 5)

The specific name is from the Nahuatlan, *Azteca,* meaning an Indian of the Nahuatlan tribe which founded the Mexican Empire, and is given because

of the occurrence of the species in the heart of the former Aztec territory in Mexico. It is closest to *unca* but is easily distinguished by the wide, impunctate shiny area adjacent to the upper rim of the anterior declivity of metasomal tergum 1, by the yellow color on the scape being reduced to a small ventrobasal patch, and by the much finer, more widely separated punctures of the frons at the middle of the frontal line.

Male. Length, 6.0 mm; forewing length, 4.1 mm; hindwing length, 3.0 mm; clypeal length, 0.46 mm; scutal length, 1.10 mm.

Head. Yellow areas: (1) paraocular area below diagonal line originating just below upper end of outer subantennal suture and extending convexly dorsolaterally tangent to facial fovea, ending on orbit slightly above level of lower border of facial fovea; (6) as in *unca;* (7) scape a small patch on ventral surface basally; flagellomeres 1-3 with tiny, successively larger patches ventrally. (8) Hairs of vertex and frons fulvous, of clypeus whitish. (10) Punctures beside lower half of frontal line, finest in the subgenus, somewhat irregularly distributed, 2-4 pwa, interspaces shiny (30×); punctures half to third of diameter of those of *unca,* much farther apart. (13) Orbital convergence ratio as 1.29:0.99,1.30. (15) Head width to head length as 2.06:1.53,1.35. (17) Eye length, mio, and flagellar length as 1.22:0.99:1.39. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.34:0.37:0.24:0.27. (19) Ocellolabral greater than clypeal width, 1.24:1.04,1.19. (20) Clypeocellar to outer subantennal sutural as 0.78:0.51,1.53. (21) Basal labial palpomere about 2.0 times length of others combined. (22) Flagellar length about 3.0 times length of scape, 1.39:0.46. (24) Scutal and scutellar shorter and longer hairs whitish to fulvous, longer hairs amberish, not dark when viewed from behind. (25) Scutal disc with punctures deep, distinct, medium sized, about two-thirds diameter of those of *unca,* 0.33 pwa, interspaces moderately shiny. (26) As in *unca* but ridges lower, fewer medial vermiform ridges, more longitudinal ridges laterally. (27) Foreleg with yellow on femur dorsoapically extending onto anterior and posterior surfaces, less extensive than that of *unca,* tibia except larger brown patch on posterior surface, basitarsus and following tarsomere, other tarsomeres pale testaceous. (28) Middle leg colored like foreleg but less yellow at apex; lengths of tibia, basitarsus, and apicotarsus as 0.90:0.78:0.87. (29) Hind leg colored like foreleg but brown patch of hind tibia much less extensive separated from base of tibia by 2 mow, tarsus brown. (30) Tegula transparent testaceous without yellow maculation. Humeral plate brown. (32) Marginal cell 6-9 and 3-4 both greater than 9-wt, 0.90:0.82: 0.78.

Metasoma. (34) As in *unca.* (35) Tergum 1 with punctures of median area smaller than on scutum, shallow but distinct, 1.5-3 pwa, interspaces moderately shiny. Declivity of tergum 1 shiny, impunctate.

Type Material. Holotype male, from Acatlán, Puebla, Sept. 11, 1948 (H. O. Wagner), is at the University of Michigan, Ann Arbor.

Remarks. This species bears on the outer posterior corner of the male volsella a hook-like projection which is like that of *unca*.

CALLIOPSIS (CALLIOPSIMA) CRYPTA Shinn

(Figs. 87-90; Map 6)

Calliopsis crypta Shinn, 1965, Amer. Mus. Novitates, 2211:15.

The specific name from the Greek *kryptos*, meaning hidden, is applied because this species remained mixed in a series of specimens of *C. chlorops* and *C. rozeni* for a long time prior to its recognition.

The differentiation of *crypta* from *rozeni* is discussed under the latter. The species is closest to *C. chlorops* and *C. kucalumea*. The male of *crypta* has the expanded middle section of sternum 8 with smoothly rounded posterior corners, whereas *chlorops* bears a tiny, posteriorly-directed, sharply-pointed process at each corner. The female of *crypta* has the mandibular base black or brownish black, whereas *chlorops* has the base cream colored. *C. crypta* is best distinguished from *C. kucalumea* by the key characters.

Female. Length, 8.6 mm; forewing length, 5.5 mm; hindwing length, 3.8 mm; clypeal length, 0.60 mm; scutal length, 1.49 mm.

Head. Cream colored areas: (1,2) as in *rozeni;* (3) dot (sometimes absent) dorsally near apex of labral plate; (5) absent on subantennal plate; (6) absent on mandible. (7) As in *rozeni* except tan areas of flagellomeres 1-4 smaller. (8) Hair of vertex mostly brown (view with integument as background). (10) Punctures beside lower half of frontal line larger than those of *rozeni,* less than 1 pwa, interspaces smooth, dull. (13) Orbital convergence ratio as 1.68:1.51,1.11. (14) As in *rozeni*. (15) Head width to head length as 2.60:1.82,1.43. (17) Eye length, mio, and flagellar length as 1.39:1.51:1.50. Flagellum slightly longer than in *rozeni*. (18) Interocellar, ocellocular, antennocular, and interantennal ratios similar to those of *rozeni,* as 0.46:0.49:0.43: 0.36. (19) Ocellolabral distance slightly greater than clypeal width, 1.53:1.45, 1.06. (20) Clypeocellar to outer subantennal sutural as 0.94:0.85, 1.10. (21) As in *rozeni*. (22) Flagellar length about 2.2 times length of scape, 1.50:0.68.

Mesosoma. (23) Cream colored areas: as in *rozeni* except dot on each pronotal lobe. (24) As in *rozeni* but short hairs of scutum fulvous, long hairs brown; short hairs and lateral long hairs of scutellum fulvous, other long hairs brown. (25) Scutal disc with punctures contiguous, larger than in *rozeni,* and larger than on midvertex, interspaces dull. (26) As in *rozeni* but more ridges and enclosure appearing somewhat duller although with interspaces shiny. (27) As in *rozeni*. (28) As in *rozeni* except spur length to length of

middle basitarsus as 0.46:0.94. (29,30,31) As in *rozeni*. (32) As in *rozeni* but ratio as 1.14:0.97:1.11 (some specimens with ratios almost identical to those in *rozeni*).

Metasoma. (34) As in *rozeni* but disc of tergum 4 with at least ten brown hairs. (35) Tergum 1 with punctures of median area smaller than on scutum, larger than in *rozeni*, dense, fairly regularly spaced, 1 pwa or less.

Male. Length, 7.3 mm; forewing length, 4.8 mm; hindwing length, 3.4 mm; clypeal length, 0.52 mm; scutal length, 1.27 mm.

Head. Yellow areas: (1) paraocular area below diagonal line originating on outer subantennal suture at level of middle of antennal socket (or below) and extending to lower margin of facial fovea ending on orbit slightly above level of lower border of facial fovea; (6) as in *rozeni*. (7) Scape entirely black (basal ventral dot or streak of yellow to a basal, ventral, narrow yellow stripe strongly attenuate apically); a dot on lateroventral surface of flagellomere 1. (10) As in female. (13) Orbital convergence ratio as 1.51:1.14,1.33. (14) As in *rozeni*. (15) Head width to head length as 2.33:1.63,1.43. (17) Eye length, mio, and flagellar length as 1.21:1.14:1.62. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.43:0.43:0.31:0.34. (19) Ocellolabral greater than clypeal width, 1.34:1.14,1.18. (20) Clypeocellar to outer subantennal sutural identical to that in *rozeni*, 0.82:0.71,1.14. (21) N. A., measured on paratype: basal labial palpomere about 2.4 times length of others combined. (22) Flagellar length about 3.1 times length of scape, 1.62:0.53.

Mesosoma. (24) As in *rozeni*, except scutal and scutellar short hairs fulvous, long hairs whitish (fulvous, or brown as seen from behind). (25) Scutal disc with punctures larger than in *rozeni* or *chlorops*, mostly 0.5 pwa (or less), interspaces shiny. (26) Dorsal enclosure of propodeum with fewer, higher ridges than that of *rozeni*, median ridges more vermiform and lateral ridges less straight than those of *rozeni*. (27) As in *rozeni*. (28) Middle leg yellow as in *rozeni*, but tibia with anterior surface splotched with brown; lengths of tibia, basitarsus, and apicotarsus about as in *rozeni*, 1.02:0.85:1.09. (29) Hind leg yellow as in *rozeni* but slightly darker, apicotarsus brown. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 0.99:0.83:0.90.

Metasoma. (34) Suberect hairs of disc of terga 4-5 brownish. (35) Tergum 1 with punctures of median area subequal to those on scutum, larger than those of *rozeni*, contiguous, becoming no more than 0.5 pwa laterad, interspaces shiny. (38) Plane of each ventral prong of sternum 6 perpendicular to surface of sternum whereas ventral prongs of other species of *Calliopsima* are tilted towards sagittal plane of body.

Type Material. Holotype male, from Rustler Park (near Apache), Chiricahua Mts., Cochise County, Arizona, Sept. 5, 1962 (J. G. Rozen, M. Statham, S. J. Hessel), and allotype female, from Portal (5 mi. W.), S.W.R.S.,

Cochise County, Arizona, 5400 ft., September 3, 1962 (J. G. Rozen, M. Statham), are at the American Museum of Natural History.

In addition 17 male and 28 female paratypes are from the following localities: Arizona: Montezuma Pass, Huachuca Mountains, Cochise Co., 6500 ft.; Portal (5 mi. W.); Rustler Park, Chiricahua Mountains, Cochise Co., 8500 ft. Chihuahua: Santa Barbara, 6200 ft.

Discussion and Distribution. An apparent case of interspecific mating with male *rozeni* is discussed above under that species. The one record from Mexico indicates that *crypta* is not strictly an endemic species of southeastern Arizona.

Flower Records. *Cirsium, Helianthus,* and *Heterotheca subaxillaris. Calliopsis crypta* shares *Helianthus* and *Heterotheca* flowers with both *C. rozeni* and *C. pectidis.*

CALLIOPSIS (CALLIOPSIMA) CHLOROPS Cockerell

(Figs. 95-98; Map 6)

Calliopsis chlorops Cockerell, 1899, *in* Cockerell and Porter, Ann. Mag. Nat. Hist., (7)4:413, male; Cockerell and Atkins, 1902, Ann. Mag. Nat. Hist., (7)10:44; Cockerell, 1906, Trans. Amer. Ent. Soc., 32:300; 1908, Canad. Ent., 40:148; 1921, Amer. Mus. Novitates, 24:14.

This species has affinities with *coloratipes,* but the preponderance of morphological similarities are with *crypta* and *unca* from which it is differentiated as discussed under those species.

Female. Length, 7.9 mm; forewing length, 5.6 mm; hindwing length, 3.65 mm; clypeal length, 0.56 mm; scutal length, 1.34 mm.

Head. Yellowish areas: (1) paraocular area as described for subgenus, sinuous line originating at about middle of outer subantennal suture, ending on orbit slightly below level of middle of facial fovea; (2) clypeus, with two longitudinal brown, to black, bars arising above apical margin of disc, or on apical margin, at angles of median emargination, reaching upward close to, to contacting, frontoclypeal suture along subantennal plate and supraclypeal area; frontoclypeal suture black; (3) labrum entirely, to only on median portion of labral plate; (5) absent on subantennal plate, to almost imperceptible dot at 30×; (6) mandible basal half. (7) Flagellomeres 1-3 dark ventrally, with tiny dot of tan, flagellomere 4 tan ventrally. (8) Hair of vertex fulvous. (10) Punctures beside lower half of frontal line smaller than those of *crypta,* larger than those of *coloratipes,* 1 pwa or more, interspaces dull. (13) Orbital convergence ratio as 1.51:1.48,1.02. (14) Galea shiny basally, finely pebbled, dull apically. (15) Head width to head length as 2.57:1.72,1.49. (17) Eye length, mio, and flagellar length as 1.29:1.48:1.43. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.46:0.46.037:0.36. (19) Ocellolabral greater than clypeal width, 1.50:1.41,1.06. (20) Clypeocellar to outer subantennal sutural as 0.94:0.78,1.20. (21) Basal labial palpomere 2.8 times length

of others combined. (22)Flagellar length about 2.2 times length of scape, 1.43: 0.65.

Mesosoma. (23) Yellowish areas: apex pronotal lobe; scutellar crest. (24) Scutal and scutellar longer hairs fulvous (to amber). Shorter hairs more plumose than those of *crypta* but scutal surface readily visible. (25) Scutal disc with punctures slightly larger than on frons, deep, crowded, contiguous to 0.5 pwa, interspaces dull. (26) Dorsal enclosure of propodeum with fine, longitudinally vermiform ridges, interspaces shiny, medial portion prolonged posteriorly, posterior border carinate. (27) Foreleg yellowish at dorsal apex of femur, knee of tibia and adjacent area subequal to it. (28) Spur length slightly more than half length of middle basitarsus, 0.44:0.83. (30) Tegula colorless to pale straw color. Humeral plate yellowish apically. (31) Stigma testaceous. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 1.24: 0.99:1.05.

Metasoma. (34) As in *crypta* but brown hairs often absent. (35) Tergum 1 with punctures of median area larger than on scutum, usually sparsely, irregularly distributed, but rarely relatively regularly distributed medially about 1-2 pwa, interspaces highly polished, mirror-like.

Male. Length, 5.3 mm; forewing length, 4.1 mm; hindwing length, 2.85 mm; clypeal length, 0.51 mm; scutal length, 1.05 mm.

Head. Yellow areas: (1) paraocular area below diagonal line originating at a point on outer subantennal suture fourth its length below its summit (or from upper end of suture) and extending tangent to facial fovea ending on orbit slightly above level of lower border of facial fovea (to about middle); (5) subantennal plate in some cases with a black triangular area in lowermost outer corner including anterior tentorial pit; (6) mandible basal half; (7) scape, a tiny basal dot (to narrow band or streak reaching as high as middle of scape to all brown). (10) Punctures beside lower half of frontal line of moderate size, smaller than those of *rozeni, unca,* and *crypta,* larger than those of *azteca, coloradensis,* or *pectidis* group, 0.5-1.5 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.29:1.02,1.27. (14) Galea lightly pebbled, dull, tip narrowly rounded. Galeal gap about half length of galea exposed beyond closed mandibles, (0.22:0.48). (15) Head width to head length as 1.96:1.41,1.39. (17) Eye length, mio, and flagellar length as 1.07:1.02:1.38. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.44:0.44: 0.27:0.31. (19) Ocellolabral greater than clypeal width, 1.22:0.97,1.26. (20) Clypeocellar to outer subantennal sutural as 0.71:0.60,1.20. (21) Basal labial palpomere 2.4 times length of others combined. (22) Flagellar length about 2.9 times length of scape, 1.38:0.48.

Mesosoma. (24) Scutal and scutellar hair grayish (to fulvous), longer hairs dark in some specimens. Shorter hairs not so dense nor so plumose as to hide scutal surface. (25) Scutal disc punctures of moderate size, smaller than

in *crypta,* mostly contiguous, interspaces shiny. (26) Dorsal enclosure of propodeum concave inward, declivous, bearing distinct, fine, relatively straight, ridges, median portion with vermiform ridges (in some cases). (27) Foreleg with yellow on anterior dorsoapical third (to half) of femur, anterior surface of tibia, all of basitarsus, apicotarsus testaceous. (28) Middle leg colored like foreleg but femoral yellow reduced to sixth (to fourth) of femur; lengths of tibia, basitarsus, and apicotarsus as 0.82:0.68:0.78. (29) Hind leg colored like foreleg but posterior surfaces of tibia and basitarsus all brown (to about four-fifths brown). (32) Marginal cell 6-9 and 3-4 greater than 9-wt, 0.92:0.85:0.80.

Metasoma. (35) Tergum 1 with punctures of median area larger than those of scutum, smaller than those of *crypta* or *rozeni,* deep, about 0.5 pwa, interspaces shiny.

TYPE MATERIAL. Holotype male, from Las Vegas, New Mexico, Aug. 9 (W. Porter), on *Grindelia squarrosa,* is at the University of California, Riverside. A microscope slide of the mouth parts, U. S. N. M. type slide No. 2390, is in the United States National Museum. The above description of the female is principally based on a specimen from Morley, Colorado. The male holotype is exceptionally small.

DISTRIBUTION. The species occurs in the Front Range of the Rocky Mountains from northern New Mexico to northern Wyoming, in the eastern part of the Great Basin, and the upper and middle portion of the Colorado Plateau. It is allopatric with *unca* and *crypta,* but in the western and southern part of its range it is sympatric with *coloratipes,* and also largely with *coloradensis.* It has been collected between July 10 at Petersboro, Utah, and Sept. 27 at Embudo, New Mexico. The highest elevations for it are 9300 and 9200 ft. at Ward, Colorado, and at Warner Ranger Station near Moab, Utah, respectively.

In addition to the type, approximately 115 males and females were examined from the following localities: ARIZONA: Del Rio Verde River vicinity, Yavapai Co.; Eagar; Flagstaff, Coconino Co.; Kirkland, Yavapai Co.; Prescott; Springerville (32 mi. W.), Apache Co. COLORADO: Boulder, 5500 ft.; Coaldale, 7800 ft.; Colorado Springs; Cortez; Durango; Florissant; Manitou; Meeker, 6200 ft.; Morley; Peaceful Valley; Ute Creek, Sage Flats; Ward, 9300 ft. IDAHO: Downey; Franklin, Franklin Co.; NEVADA: Ely (9 mi. W.); Glorieta; Las Vegas; Pecos; Raton; Santa Fe. UTAH: Aspen Grove; Ballard; Devils Slide, Summit Co.; Garfield; Logan; Magna; Moab (28 mi. E.S.E.), Warner Ranger Station, Grand Co., 9200 ft.; Morgan, Morgan Co.; Murray; Petersboro, Cache Co.; Salt Lake City, 5000 ft.; Sandy, Salt Lake Co.; Spanish Fork, Utah Co.; Wellsville, Cache Co. WYOMING: Wheatland; Yellowstone National Park.

FLOWER RECORDS. *Haplopappus gracilis, Chrysopsis, Grindelia squarrosa, Medicago sativa, Ratibida, Verbesina, Viguiera annua.*

CALLIOPSIS (CALLIOPSIMA) COLORATIPES Cockerell

(Figs. 99-192; Map 5)

Calliopsis flavifrons race *coloratipes* Cockerell, 1898, Bull. Denison Univ. Sci. Labs., 11:52, male; *idem,* Bull. Univ. New Mexico, 1:52.

Calliopsis coloradensis coloratipes; Cockerell, 1900, Entomologist, 33:64, female; *idem,* 1906, Trans. Amer. Ent. Soc., 32:300.
Calliopsis coloratipes; Cockerell, 1908, Canad. Ent., 40:148; *idem,* 1921, Amer. Mus. Novitates, 24:14.

Outside of its own group this species is close to *coloradensis* and has morphological similarities to *chlorops.* Within its own group it is closest to *deserticola.* The male is easily distinguished by the mesally-tilted, conspicuous ventral prongs of sternum 6 whereas prongs are absent in *deserticola.* The female is separated from *deserticola* only with difficulty, but the dorsal enclosure of the propodeum is very shiny in *coloratipes* and quite dull in *deserticola* (20×); moreover, the ridges are straight and 1-2 ridge widths apart in *coloratipes,* but are vermiform and run together in *deserticola.*

Female. Length, 7.6 mm; forewing length, 5.3 mm; hindwing length, 3.71 mm; clypeal length, 0.54 mm; scutal length, 1.36 mm.

Head. Cream colored areas: (1) paraocular area as described for subgenus, dorsal boundary a straight, to sinuous, line originating at upper end of outer subantennal suture, ending on orbit at about level of middle of facial fovea; (2) clypeus as in *chlorops* except many specimens without brown bars, with only two small, brown clypeal dots; labrum all yellow to all brown; (5) subantennal plate except for subtriangular black area at lower end of outer subantennal suture, to mostly dark; (6) mandible basal half. (7) Flagellomeres 1-4 black with tiny amount of tan. (8) Hair of vertex fulvous. (10) Punctures beside lower half of frontal line fine, 2-4 pwa, interspaces dull (to shiny). (13) Orbital convergence ratio as 1.60:1.50,1.07. (14) Galea finely pebbled, dull. Galeal length 1.10. (15) Head width to head length as 2.52: 1.72,1.46. (17) Eye length, mio, and flagellar length as 1.26:1.50:1.31. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.48:0.46:0.39:0.36. (19) Ocellolabral greater than clypeal width, 1.46:0.94, 1.56. (20) Clypeocellar to outer subantennal sutural as 0.92:0.80,1.15. (21) Basal labial palpomere 2.4 times length of others combined. (22) Flagellar length about 2.3 times length of scape, 1.31:0.56.

Mesosoma. (23) Cream colored areas: apex pronotal lobe; scutellar crest. (24) Scutal and scutellar longer hairs fulvous (to amber). Shorter hairs more plumose than those of *chlorops,* in some cases hiding scutal surface. (25) Scutal disc with punctures fine, about twice diameter of those on frons, finer than in *chlorops,* deep, crowded, mostly 0.5 pwa, interspaces shiny. (26) Dorsal enclosure of propodeum with relatively straight shiny ridges separated by 1-2 ridge widths, interspaces shiny, median portion prolonged only slightly, posterior border carinate; a highly polished, impunctate band on vertical surface of propodeal triangle adjacent to enclosure. (27) Foreleg cream colored at dorsal apex of femur and basal third to half of dorsal tibial surface. (28) Middle leg colored like foreleg but about half as much cream color. Spur

length less than half length of middle basitarsus, 0.44:0.92. (30) Tegula testaceous. Humeral plate cream colored apically. (31) Stigma testaceous. (32) Marginal cell 6-9 and 3-4 both greater than 9-wt, 1.12:1.00:0.94.

Metasoma. (34) Suberect hairs of discs of terga 4-5 white. (35) Tergum 1 with punctures of median area smaller than on scutum, finer than in *chlorops,* very sparsely, irregularly distributed to virtually absent, tergum highly polished, mirror-like.

Male. Length, 6.5 mm; forewing length, 4.4 mm; hindwing length, 4.0 mm; clypeal length, 0.53 mm; scutal length, 1.22 mm.

Head. Yellowish areas: (1) paraocular area below diagonal line originating at upper end of outer subantennal suture (to fourth length of suture below upper end), ending on orbit below level of middle of facial fovea; (6) mandible basal half; (7) scape anterior surface except for narrow brown strip mesally, slightly widened mesoapically. (10) Punctures beside lower half of frontal line extremely fine, 1-2 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.45:1.09,1.33. (14) Galea pebbled, dull apically, tip narrowly rounded. Galeal gap about half length of galea exposed beyond closed mandibles, 0.22:0.44. (15) Head width to head length as 2.26:1.55,1.46. (17) Eye length, mio, and flagellar length as 1.24:1:09:1.45. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.46:0.39:0.26:0.31. (19) Ocellolabral greater than clypeal width, 1.28:1.16,1.10. (20) Clypeocellar to outer subantennal sutural as 0.75:0.66,1.13. (21) Basal labial palpomere about 2.2 times length of others combined. (22) Flagellar length about 2.9 times length of scape, 1.45:0.49.

Mesosoma. (24) Scutal and scutellar shorter hairs fulvous, plumose, tending to hide scutal surface. (25) Scutal disc with punctures smaller than those of *chlorops,* mostly 0.5 pwa, interspaces shiny. (26) Dorsal enclosure of propodeum as in *chlorops* except ridges finer, straighter, much shinier; median portion barely (or not) produced posteriorly, medial length about 0.26, or about 1.5 mow. (27,28,29) As in *chlorops* but posterior surface of hind tibia sometimes half yellow basally; lengths of tibia, basitarsus, and apicotarsus as 0.87:0.77:0.77. (32) Marginal cell 6-9 greater than, and 3-4 subequal to 9-wt, 1.04:0.83:0.82.

Metasoma. (35) Tergum 1 with punctures of median area smaller than those of scutum, smaller than those of *chlorops,* about 0.5 pwa, interspaces shiny.

Type Material. Holotype male, from Mesilla, New Mexico, Aug. 12 (T. D. A. Cockerell), is at the University of California, Riverside. The above description of the female is principally based on a specimen of a pair taken *in copulo* at Mesilla Park, New Mexico, Sept. 1 (T. D. A. Cockerell), on *Bigelovia wrighti.*

Distribution. The southern Great Basin and the Colorado Plateau. Its range is partially sympatric with *coloradensis* and *chlorops*, but it is wholly allopatric with *deserticola* and *pugionis*. It has been collected from July 2, at Carson City, Nevada, to Oct. 23, at Phoenix, Arizona, a distinct difference from its nearest relative, *deserticola*, which is a spring bee.

In addition to the type approximately 41 specimens have been examined from the following localities: Arizona: Apache (6 mi. S.E.), Skeleton Canyon; Cochise (2 mi. N.); Florence; Phoenix; San Xavier Mission; Tempe; Tucson; Willcox; "Southern Arizona." Nevada: Carson City, Ormsby Co.; Yerrington (8.5 mi. S.), Lyon Co. New Mexico: Jemez Springs, Sandoval Co.; Mesilla; Mesilla Park. Utah: Hinckley, Millard Co.; Milford, Beaver Co.; Topaz, Juab Co.

Geographic Variation. Specimens from Utah and Nevada have a longer galea, a more protruding clypeus in the female, and tend to be darker than those from Arizona and New Mexico. Two male specimens from Willcox, Arizona, Aug. 1956 (Ellen Ordway) and 1958 (E. G. Linsley), the latter on *Baileya pleniradiata*, differ from other *coloratipes* by having white face markings with scape yellow, a combination also found in *squamifera*.

Discussion. *C. coloratipes* appears to have given rise to *deserticola* in the southwestern extreme of its range. The basal cream color of the mandible and the sparsely punctate median portion of tergum 1 indicate a relationship to *chlorops*. The cream colored subantennal plates of *coloratipes* are correspondingly black in *chlorops* and either black or partly cream-colored in *coloradensis*. The smaller punctures of *coloratipes* and the straight-ridged character of the dorsal enclosure of the propodeum betoken a relationship with *coloradensis*.

Flower Records. *Asclepias subverticillata, in copulo* on both *Bigelovia hartwegi* and *B. wrightii, Chrysothamnus* sp., *C. nauseosus consimilis, Heterotheca*.

CALLIOPSIS (CALLIOPSIMA) DESERTICOLA, new species

(Figs. 103-106; Map 5)

The specific name is compounded from the Latin *desertum*, a waste place, and *-cola*, dwelling in, in reference to its occurrence in the Colorado Desert in California. The species was recognized as new by P. H. Timberlake a number of years ago, and his manuscript name is used here.

Judged by the male it is closest to *pugionis*, but judged by the female it is closest to *coloratipes*. The male is distinguished by the ratio of the length of galea exposed beyond closed mandibles to the galeal gap being 3.5-4.5, whereas in *pugionis* it is 2-3; *C. deserticola* is easily distinguished from *coloratipes* by the absence of ventral prongs on sternum 6. The female is easily distinguished from *pugionis* by its cream colored, rather than deep lemon yellow, face. It is distinguished from *coloratipes* only with difficulty as discussed under that species.

Female. Length, 7.5 mm; forewing length, 4.8 mm; hindwing length, 3.30 mm; clypeal length, 0.60 mm; scutal length, 1.22 mm.

Head. Pale yellowish areas: (1) paraocular area, as described for subgenus, sinuous line originating about middle of outer subantennal suture (lower than in *coloratipes!*) and ending on orbit about 0.33 (or less) times length of facial fovea above its lower border; (2) as in *chlorops;* (3) labrum entirely; (5) subantennal plate a spot touching lower border of antennal socket; (6) mandible basal half. (7) As in *coloratipes* but lighter. (8) Hair of vertex pale fulvous. (10) Punctures beside lower half of frontal line exceedingly fine, slightly finer than those of *pugionis,* shallow, 1-3 pwa, interspaces highly polished. (13) Orbital convergence ratio 1.45:1.38,1.05. (14) Galea very finely pebbled, moderately shiny. Galeal length 1.19. (15) Head width to head length as 2.36:1.73,1.36. (17) Eye length, mio, and flagellar length as 1.26:1.38:1.31. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.43:0.41:0.37:0.37. (19) Ocellolabral greater than clypeal width, 1.48: 1.45,1.02. (20) Clypeocellar to outer subantennal sutural as 0.88:0.77,1.15. (21) Basal labial palpomere about 2.2 times length of others combined. (22) Flagellar length about 2.3 times length of scape, 1.31:0.56.

Mesosoma. (23) Yellowish areas: apex pronotal lobe (in some cases); scutellar crest. (24) Scutal and scutellar hairs pale fulvous. Shorter hairs as plumose as in *chlorops,* tending to hide scutal surface; longer hairs shorter, more plumose than in *coloratipes.* (25) Scutal disc with punctures finer, shallower and farther apart, 1-2 pwa, than in *coloratipes,* interspaces shiny. (26) Dorsal enclosure of propodeum with numerous close-packed, ultra fine, vermiform ridges, dull (20×); median portion scarcely (or not at all) prolonged posteriorly, posterior border non-carinate; an impunctate, highly polished adjacent band of propodeal triangle present as in *coloratipes.* (27) Foreleg yellowish at dorsal apex of femur, knee of tibia and adjacent area subequal to it. (28) Middle leg colored like foreleg but about half as much yellow color; spur length about half of length of middle basitarsus, 0.43:0.85. (30) Tegula testaceous. Humeral plate yellowish apically. (31) Stigma brown. (32) Marginal cell 6-9 and 3-4 both greater than 9-wt, 1.12:1.00:0.94.

Metasoma. (34) Tergal hair bands sparser, hairs slimmer, less plumose than in *coloratipes.* Suberect hairs of terga 4-5 white. (35) Tergum 1 with punctures of median area much smaller than on scutum, finer than in *coloratipes,* very sparsely irregularly distributed to virtually absent; tergum highly polished, mirror-like.

Male. Length, 7.3 mm; forewing length, 4.8 mm; hindwing length, 3.25 mm; clypeal length, 0.56 mm; scutal length, 1.21 mm.

Head. Yellow areas: (1) paraocular area as in *coloratipes* but dorsal boundary line may extend along orbit only to level of lower border of facial fovea; (5) subantennal plate sometimes with yellow reduced by subtriangular

black area around anterior tentorial pit; (6) mandible basal half; (7) scape as in *coloratipes,* flagellomere 1 yellow ventrally. (10) Punctures beside lower half of frontal line exceedingly fine, larger than those of *azteca* or *deserticola,* 1-2 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.39:1.16,1.21. (14) Galea pebbled, dull, tip broadly rounded. Galeal gap about fourth of length of galea exposed beyond closed mandibles, 0.15:0.68. (15) Head width to head length as 2.26:1.72,1.31. (17) Eye length, mio, and flagellar length as 1.22:1.16:1.55. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.46:0.39:0.27:0.34. (19) Ocellolabral greater than clypeal width, 1:38:1.22, 1.13. (20) Clypeocellar to outer subantennal sutural as 0.82:0.71,1.14. (21) Basal labial palpomere about 2.1 times length of others combined. (22) Flagellar length about 3.1 times length of scape, 1:55:0.49.

Mesosoma. (24) Scutal and scutellar hair grayish white, shorter hairs somewhat plumose, tending to hide scutal surface as in *coloratipes.* (25) Scutal disc with punctures smaller than in *coloratipes,* mostly 1-1.5 pwa, interspaces shiny. (26) Dorsal enclosure of propodeum declivous, dull, bearing very fine, obscurely vermiform, ridges; enclosure shorter than others in its group, about 1 mow medially, median portion not produced posteriorly. (27) Foreleg as in *coloratipes* but posterior surface of basitarsus sometimes testaceous. (28) Middle leg with yellow on dorsoapical fourth (to third) of femur, a stripe along tibia and basitarsus anteroventrally, apicotarsus testaceous; light coloration sometimes as unevenly splotched areas; length of tibia, basitarsus, and apicotarsus as 0.99:0.88:0.95. (29) Hind leg colored like middle leg but less extensive yellow, absent from basitarsus (in some cases), tarsus brown; light coloration sometimes as unevenly splotched areas. (32) Marginal cell 6-9 and 3-4 both greater than 9-wt, 1.12:0.94:0.82.

Metasoma. (35) Tergum 1 with punctures of median area subequal to those of scutum, smaller than those of *coloratipes,* 0.5-1 pwa, interspaces shiny. Declivity of tergum 1 with more than 25 fine, deep, distinct punctures, mostly grouped laterally below dorsal margin.

Type Material. Holotype male, from Painted Gorge, southeast corner of Anza Desert State Park north of Coyote Wells, Imperial Co., California, April 12, 1949 (R. A. Hoch), on *Encelia farinosa,* and allotype female, Box Canyon, near Mecca, Riverside Co., April 14, 1935 (P. H. Timberlake), on *Encelia farinosa,* are at the University of California, Riverside. Paratypes are at the Snow Entomological Museum of The University of Kansas and in the author's collection.

In addition, 12 male and 4 female paratypes are from the following localities: California: Box Canyon, Riverside Co., 5 males, 3 females, April 14, 1935 (P. H. Timberlake), on *Encelia farinosa;* Needles, San Bernardino Co., 3 males, 2 females, April 3, 1951 (P. D. Hurd), 2 males, same data except (E. G. Linsley); Painted Gorge, Imperial Co., 2 males, April 12, 1949 (R. A. Hoch), on *Encelia farinosa.*

CALLIOPSIS (CALLIOPSIMA) PUGIONIS Cockerell

(Figs. 107-110; Map 5)

Calliopsis pugionis Cockerell, 1925, Proc. California Acad. Sci., (4) 14:197, female.

The specific name is from the Latin *pugio,* meaning dagger, and refers to the dagger-shaped, yellow median line on the clypeus of the female holotype. The species is closest to *deserticola. C. pugionis* is distinguished in the male by the very deep, distinct, large, contiguous punctures of the median portion of tergum 1 whereas those of *deserticola* are not nearly so deep nor distinct, are of medium size and are mostly 1 pwa. The female is easily distinguished by the deep lemon yellow facial coloring in contrast with the cream or pale yellowish facial coloring of *deserticola.* Both sexes are distinguished from *deserticola* by the galeal gap being greater than the middle ocellar width, and by the galeal length being only about six-sevenths that of *deserticola.*

Female. Length, 8.0 mm; forewing length, 5.5 mm; hindwing length, 3.67 mm; clypeal length, 0.58 mm; scutal length, 1.32 mm.

Head. Deep lemon yellow areas: (1) paraocular area as described for subgenus, sinuous line originating slightly above middle of outer subantennal suture, ending on orbit at level of lower third or less of facial fovea; (2) clypeus with wide, twin vertical brown or black bars arising near angles of median apical emargination, frequently joined by subapical brown band, reaching close to frontoclypeal suture, the bars separated by a dagger-shaped yellow area less than 1 mow in width; brown bars strikingly similar to those in *coloradensis;* (3) labrum almost entirely to absent; (5) subantennal plate with small spot, or absent; (6) mandible basal fifth to absent. (7) Flagellomeres 1-4 brown and tan ventrally. (8) Hair of vertex amber with brownish tips. (10) Punctures beside lower half of frontal line exceedingly fine, finest in the subgenus, deep, 2-4 pwa, interspaces highly polished. (13) Orbital convergence ratio as 1:58:1.48,1.07. (14) Galea finely pebbled, dull. Galeal length about six-sevenths that of galeal length of *deserticola,* 1.02. (15) Head width to head length as 2.48:1.80,1.38. (17) Eye length, mio, and flagellar length as 1.36:1.48:1.33. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.49:0.48:0.41:0.37. Antennocular equal to or greater than interantennal! (19) Ocellolabral equal (to subequal) to clypeal width, 1.50:1.50, 1.00. (20) Clypeocellar to outer subantennal sutural as 0.92:0.78,1.17. (21) Basal labial palpomere about 2.5 times length of others combined. (22) Flagellar length about 2.2 times length of scape, 1.33:0.60.

Mesosoma. (23) Yellow areas: apex pronotal lobe; scutellar crest (sometimes), or testaceous. (24) Scutal and scutellar longer hairs amberish, apical portion frequently brownish. Shorter hairs plumose as in *deserticola,* tending to hide scutal surface; longer hairs as in *deserticola.* (25) Scutal disc with punctures finest in subgenus, deep, 1 pwa or less, interspaces shiny. (26)

Dorsal enclosure of propodeum with somewhat fewer, more distinct, very fine vermiform ridges, usually dull but shinier, than in *deserticola;* median portion slightly prolonged posteriorly, posterior border carinate; impunctate, polished adjacent band of propodeal triangle narrower than in *deserticola.* (27) Foreleg deep lemon yellow with same extent as yellowish on foreleg of *deserticola.* (28) Middle leg deep lemon yellow with same extent as yellowish on middle leg of *deserticola;* spur length half of length of middle basitarsus, 0.44:0.88. (30) Tegula testaceous. Humeral plate yellow to testaceous apically. (31) As in *deserticola.* (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 1.09:0.90:1.04.

Metasoma. (34) Tergal hair bands denser than in *deserticola.* Suberect hairs of terga 4-5 white. (35) Tergum 1 with punctures of median area much smaller than on scutum, about same size or larger than those in *deserticola,* very sparsely, irregularly distributed to virtually absent; tergum highly polished, mirror-like.

Male. Length, 7.5 mm; forewing length, 5.3 mm; hindwing length, 3.6 mm; clypeal length, 0.61 mm; scutal length, 1.34 mm.

Head. Deep lemon yellow areas: (1) as in *deserticola;* (6) mandible basal half; (7) scape as in *deserticola* (variable, to only basal spot with streak extending dorsally from it). (10) Punctures beside lower half of frontal line larger than those of *deserticola,* smaller than those of *coloratipes,* mostly 1 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.58:1.22,1.29. (14) Galea pebbled, dull, tip broadly rounded. Galeal gap about half length of galea exposed beyond closed mandibles, 0.26:0.58. (15) Head width/head length as 2.52:1.87,1.34. (17) Eye length, mio, and flagellar length as 1.43: 1.22:1.62. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.44:0.46:0.27:0.36. (19) Ocellolabral greater than clypeal width, 1.50:1.39, 1.07. (20) Clypeocellar to outer subantennal sutural as 0.88:0.75,1.18. (21) Basal labial palpomere about 2.4 times length of others combined. (22) Flagellar length about 3.0 times length of scape, 1.62:0.54.

Mesosoma. (24) Scutal and scutellar shorter hairs grayish white, nonplumose, not hiding scutal surface as in *deserticola.* (25) Scutal disc with punctures larger than in deserticola, mostly 1-1.5 pwa, interspaces shiny. (26) Dorsal enclosure of propodeum declivous, dull, bearing fine (but coarser than in *deserticola*), obscurely vermiform ridges; enclosure not produced posteriorly but long, length about 0.31, or 1.7 mow. (27) Same note as for *deserticola.* Foreleg colored like that of *deserticola* but basitarsus may be brown. (28) Middle leg colored like that of *deserticola* except tarsus may be brown; lengths of tibia, basitarsus, and apicotarsus as 1.12:0.92:0.99. (29) Hind leg colored like that of *deserticola.* (32) Marginal cell 6-9 longer than, and 3-4 shorter than 9-wt, 1.12:0.90:0.94.

Metasoma. (35) Tergum 1 with punctures of median area larger, deeper than those of scutum, very coarse, larger than those of *coloratipes* or *deserticola,* contiguous, interspaces shiny, but tergum *in toto* rather dull. Declivity of tergum 1 with more than 25 coarse deep, distinct punctures, mostly grouped about third of length of declivity below the dorsal margin.

TYPE MATERIAL. Holotype female, from Soboba Springs, Riverside Co., California, June 3, 1917 (E. P. Van Duzee), is Type No. 1657 at the California Academy of Sciences, San Francisco. The above description of the female is principally based on a specimen from Palm Springs, Taquitz Canyon, California, April 16, 1938 (R. M. and G. E. Bohart) while that of the male is based on a specimen from Riverside, California, May 3, 1928 (P. H. Timberlake), on garden *Coreopsis.*

DISTRIBUTION. Known only from San Diego, Riverside, and Los Angeles counties in southwestern California. It is a spring bee collected from April 6 to June 14.

I have not examined the type but have studied approximately 70 males and females from the following localities: CALIFORNIA: Acton, Mint Canyon, Los Angeles Co., May 3, 1936 (E. G. Linsley), on *Chaenactis;* Dulzura, June 14, 1917; Newhall, Los Angeles Co., April 20, 1940 (R. M. Bohart); Palm Springs, Andreas Canyon, Riverside Co., March 24 and April 11, 1936 (P. H. Timberlake), *Encelia farinosa; idem,* April 10, 1936, *Encelia farinosa,* April 6, 1939 (both C. D. Michener); *idem,* April 7, 1940 (R. M. Bohart); Palm Springs, Palm Canyon, April 15, 1938 (R. M. and G. E. Bohart), *Encelia farinosa;* Palm Springs, Taquitz Canyon, April 16, 1938 (R. M. and G. E. Bohart); Gavilan (between Perris and Lake Mathew), Riverside Co., 2200 feet, May 15, 1936 (P. H. Timberlake), *Chaenactis artemisiaefolia; idem,* but no altitude given, April 18, 1940 (P. H. Timberlake), *Oenothera ocitebrana;* Riverside, April 25, 1929, April 28, 1934, Aug. 5, 1938, all on *Chaenactis glabrisscula,* May 3, 1928, *in copulo* on garden *Coreopsis,* May 17, 1929, June 7, 1927, both on *Coreopsis,* May 12, 1932, May 13, 15, 16, 1929, all on *Coreopsis lanceolata,* May 31 and June 9, 1927, *Hemizonia wrighti* (all P. H. Timberlake).

DISCUSSION. Although Cockerell considered this species as nearest to *coloradensis* it is really a rather distant relative. The color pattern of the legs of the male is very close to that of *deserticola,* and the color patterns of the legs of both species are remarkably similar to those of *hurdi* and *kucalumea.* I believe that *pugionis* is a relict of a formerly widespread population of *deserticola.*

FLOWER RECORDS. *Chaenactis artemisiaefolia, C. glabrisscula, Coreopsis* (cultivated), *C. lanceolata, Encelia farinosa, Hemizonia wrighti, Oenothera ocitebrana.*

CALLIOPSIS (CALLIOPSIMA) HURDI, new species

(Figs. 111-114; Map 5)

This species, the largest one of the genus, is named for Dr. Paul D. Hurd, Jr., in grateful acknowledgement of his loans of many important specimens for my study of the genus.

The closest relative is *kucalumea* from which it is best distinguished by the key characters in couplet 24 for males, and in couplet 32 for females.

Females. Length, 9.8 mm; forewing length, 7.0 mm; hindwing length, 5.00 mm; clypeal length, 0.65 mm; scutal length, 1.78 mm.

Head. Pale yellow areas: (1) paraocular area as described for subgenus, sinuous line originating below middle of outer subantennal suture and ending on orbit at about level of third length of facial fovea above its lower border; (2) clypeus with wide, twin, vertical black bars arising on clypeal apex near angles of median apical emargination, reaching close to frontoclypeal suture, the bars separated by a finger of yellow 1 mow in width; color pattern similar to that of *coloradensis;* (3) absent on labrum; (5) absent on subantennal plate; (6) absent on mandible. (7) Flagellomeres missing. (8) Hair of vertex brown. (10) Punctures beside lower half of frontal line of medium size about the same size as those of *chlorops,* 1 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.96:1.82,1.07. (14) Galea finely pebbled, slightly shiny. Galeal length greatly exceeding that of *kucalumea,* 1.39:0.99. (15) Head width to head length as 3.06:2.12,1.44. (17) Eye length to mio as 1.63: 1.82, flagellum missing. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.49:0.58:0.49:0.46. (19) Ocellolabral less than clypeal width, 1.79: 1.96,0.91. (20) Clypeocellar to outer subantennal sutural as 1.12:0.95,1.18. (21) Basal labial palpomere about 3.3 times length of others combined. (22) Length of scape 0.82, flagellum missing.

Mesosoma. (23) Yellow areas: absent from apex of pronotal lobe and scutellar crest. (24) Scutal and scutellar longer hairs black. (25) Scutal disc with punctures small, deep, crowded to contiguous, interspaces shiny, scutal surface completely visible from above. (26) Dorsal enclosure of propodeum relatively dull with many longitudinally vermiform, distinctly separated ridges; median portion prolonged posteriorly, posterior border carinate. (27) Foreleg with yellow tibial knee. (28) Spur length slightly more than half of length of middle basitarsus, 0.58:1.10. (30) Tegula brown. Humeral plate brown. (31) Wing brownish. Stigma brown. (32) Marginal cell 6-9 greater than, and 3-4 less than 9-wt, 1.48:1.16:1.33.

Metasoma. (34) Suberect hairs of disc of tergum 4 brown, of disc of tergum 5 smoky. (35) Tergum 1 with punctures of median area smaller than on scutum, absent from narrow band immediately behind declivity, 2 pwa, interspaces minutely roughened, dull. Area immediately behind declivity laterally, impunctate, high polished.

Male. Length, 8.0 mm; forewing length, 5.6 mm; hindwing length, 4.0 mm; clypeal length, 0.63 mm; scutal length, 1.44 mm.

Head. Yellow areas: (1) paraocular area below diagonal line originating slightly below middle of outer subantennal suture and ending on orbit at about level of lower border of facial fovea; (3) labrum except coarsely punctate apical area (to all yellow): (5) absent from subantennal plate (to yellow

except for subtriangular black area around anterior tentorial pit); anterior tentorial pit smaller, more distinct than in other groups of *Calliopsima;* (6) mandible basal fourth (to almost absent). (7) Scape brownish black. (10) Punctures beside lower half of frontal line of moderate size, larger than in *chlorops,* mostly 1 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.60:1.33,1.27. (14) Galea almost imperceptibly roughened (30×), shiny, tip narrowly rounded. Galeal gap fourth of length of galea exposed beyond closed mandibles, (0.17:0.68). (15) Head width to head length as 2.58:1.87, 1.38. (17) Eye length, mio, and flagellar as 1.36:1.33:1.75. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.44:0.51:0.32:0.39. Interocellar less than ocellocular! (19) Ocellolabral greater than clypeal width, 1.56:1.41, 1.11. (20) Clypeocellar to outer subantennal as 0.94:0.82,1.14. (21) Basal labial palpomere about 3.2 times length of others combined. (22) Flagellar length about 2.9 times length of scape, 1.75:0.61.

Mesosoma. (24) Scutal and scutellar shorter hairs grayish white, longer hairs brown; longer hairs of metanotum and propodeum more plumose than in *quadridentata* or *kucalumea.* (25) Scutal disc with punctures of moderate size about 0.017-0.025 in diam., deep, distinct, mostly less than 0.5-1 pwa, interspaces shiny. (26) Dorsal enclosure of propodeum subhorizontal, bearing strong distinct, straight, longitudinal ridges laterally with shiny interspaces; median portion with slightly vermiform ridges; median portion produced posteriorly; length about 0.24, or about 1.3 mow. (27) Same note as for *deserticola.* Foreleg colored like that of *pugionis* except light color less extensive, yellow confined to basal half of anterior surface of basitarsus. (28) Middle leg with yellow on tibial knee; lengths of tibia, basitarsus, and apicotarsus as 1.09:0.97:1.05. (29) Hind leg with yellow on disc of basitibial plate (absent sometimes) and irregular splotch and/or dot on anterior surface of tibia preapically (usually). (30) Tegula brown without yellow patch. Humeral plate brown. (32) Marginal cell 6-9 and 3-4 greater than 9-wt, 1.21: 1.07:0.88.

Metasoma. (35) Tergum 1 with punctures of median area subequal to those of scutum, size intermediate between those of *coloratipes* and *chlorops,* 0.5-1 pwa, interspaces shiny (anterior median portion sometimes finely roughened).

Type Material. Holotype male and allotype female, from Soyalo (7 mi. S.E.), Chiapas, (R. C. Bechtel and E. I. Schlinger), are at the University of California, Berkeley. Of four male paratypes, same data as above except Simojovel (4 mi. S.W.), two are at the California Academy of Sciences, San Francisco, one is at the Snow Entomological Museum of The University of Kansas, Lawrence, and one is in the author's collection.

Distribution. This species represents the southernmost record for the subgenus *Calliopsima.* Since habitats similar to those known for *Calliopsima*

occur far south of this, and since I feel that *Calliopsima* is an intruder from South America, I anticipate discoveries of other species farther south when collections are made during the proper season.

CALLIOPSIS (CALLIOPSIMA) QUADRIDENTATA, new species

(Figs. 115-118; Map 5)

The specific name is compounded from the Latin words *quatuor,* four, and *dentata,* toothed, and is given in reference to the four tooth-like projections of the genital capsule, a condition unique in the genus and possibly in the Panurginae.

It is probably closest to *hurdi* but is easily separated from it by the yellow coloration on the anterior portion of the tegula and the more extensive yellow of the anterior surfaces of the middle and hind tibiae as well as the larger punctures of tergum 1 and larger ridges of the dorsal enclosure of the propodeum.

The male of this species is separated from *kucalumea* by the very long galea and labial palp as described in (14) and (21) below.

Male. Length, 6.5 mm; forewing length, 5.1 mm; hindwing length, 3.60 mm; clypeal length, 0.56 mm; scutal length, 1.27 mm.

Head. Yellow areas: (1) paraocular area as in *hurdi* but boundary line ending on orbit slightly above level of lower border of facial fovea; (6) mandible basal half. (7) Scape brownish black. (10) As in *hurdi* but larger. (13) Orbital convergence ratio as 1.55:1.16,1.34. (14) Galea finely, distinctly pebbled, relatively shiny, tip narrowly rounded. Galeal gap about fourth of length of galea exposed beyond closed mandibles, 0.17:0.68. (15) Head width to head length as 2.33:1.72,1.38. (17) Eye length, mio, and flagellar length as 1.21:1.16:1.68. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.43:0.46:0.29:0.34. Interocellar less than ocellocular! (19) Ocellolabral greater than clypeal width, 1.41:1.16,1.22. (20) Clypeocellar to outer subantennal sutural as 0.85:0.70,1.22. (21) Basal labial palpomere of paratype 3.2 times length of others combined. (22) Flagellar length about 3.3 times length of scape, 1.68:0.51.

Mesosoma. (24) Scutal and scutellar shorter hairs grayish-white, not hiding scutal surface, longer hairs amberish with tips darkened. (25) Scutal disc with punctures slightly larger than in *hurdi,* deeper, more distinct, contiguous, interspaces shiny but scutum appearing rather dull (20×). (26) Dorsal enclosure of propodeum declivous, intermediate between *hurdi* and *kucalumea;* pattern of ridges as in *hurdi* except finer, closer; median portion, somewhat produced, length about 0.26, or 1.5 mow. (27,28.29) Front, middle, and hind legs colored like those of *pugionis.* (30) Tegula brown with yellow anterior

patch. Humeral plate with tiny apical yellow dot. (31) Wing clear, stigma testaceous. (32) Marginal cell 6-9 and 3-4 both greater than 9-wt, 1.07:0.88: 0.78.

Metasoma. (34) As described for female of subgenus. (35) Tergum 1 with punctures of median area subequal to those of scutum, as large as those of *crypta,* but punctures of lateral area smaller than those of *crypta,* 0.5 pwa, interspaces shiny.

Type Material. Holotype male, from Lagos de Moreno, Jalisco, 6400 ft., Aug. 21, 1954 (C. D. Michener and party), is at the Snow Entomological Museum of The University of Kansas, Lawrence, and one male paratype, same data, is in the author's collection.

CALLIOPSIS (CALLIOPSIMA) KUCALUMEA, new species

(Figs. 119-122; Map 7)

The specific name is an acronym formed from Kansas University and California University Mexican Expeditions and is given to this species in recognition of the valuable specimens for this study which have come from several separate expeditions into Mexico made by the two universities.

The species is closest to *hurdi* and is best separated from it by the key characters in couplet 24 for males, and in couplet 32 for females.

Female. Length, 9.0 mm; forewing length, 6.3 mm; hindwing length, 4.35 mm; clypeal length, 0.60 mm; scutal length, 1.68 mm.

Head. Pale yellow areas: (1) as in *hurdi;* (2) clypeus with twin black bars as in *hurdi* (to median portion of clypeus all black except streak of yellow along frontoclypeal suture bordering supraclypeal area); (3,5,6) as in *hurdi.* (7) Flagellomeres 1-2 black ventrally, 3-4 mostly black ventrally with some tan. (8) Hair of vertex fulvous, with brownish tips (all fulvous, or all brownish). (10) Punctures beside lower half of frontal line smaller than those of *hurdi,* deep, 1-2 pwa, interspaces shiny. (13) Orbital convergence ratio as 1.77:1.63,1.08. (14) Galea finely pebbled, slightly shiny. Galeal length much less than in *hurdi,* 0.99:1.39. (15) Head width to head length as 2:72: 1.96,1.39. (17) Eye length, mio, and flagellar length as 1.38:1.63:1.55. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.49:0.54:0.49:0.46. (19) Ocellolabral less than clypeal width, 1:60:1.63,0.98. (20) Clypeocellar to outer subantennal sutural as 1.00:0.88,1.13. (21) Basal labial palpomere about 2.3 times length of others combined. (22) Flagellar length about 2.2 times length of scape, 1.55:0.71.

Mesosoma. (23) As in *hurdi.* (24) Scutal and scutellar longer hairs amberish to brownish. (25) Scutal disc with punctures as in *hurdi,* scutal surface less visible than in *hurdi* because of greater plumosity of scutal shorter hairs. (26) Dorsal enclosure of propodeum slightly shinier than in *hurdi,*

ridges fewer, straighter; median portion prolonged posteriorly; posterior border carinate. (27) Foreleg with yellow tibial knee. (28) Spur length more than half of length of middle basitarsus, 0.53:0.97. (30) Tegula brown. Humeral plate brown with apical yellow spot. (31) Wing brownish, clearer than in *hurdi*. Stigma brown. (32) Marginal cell 6-9 greater than, and 3-4 subequal to 9-wt, 1.38:1.17:1.16.

Metasoma. (34) Suberect hairs of disc of tergum 4 fulvous, of disc of tergum 5 mixed white and fulvous. (35) Tergum 1 with punctures of median area smaller than on scutum, deep, mostly less than 1 pwa.

Male. Length, 7.2 mm; forewing length, 5.4 mm; hindwing length, 3.70 mm; clypeal length, 0.58 mm; scutal length, 1.43 mm.

Head. Yellow areas: (1) paraocular area as in *hurdi;* (5) subantennal plate, a tiny spot (to all yellow except for black subtriangular area around anterior tentorial pit); (6) mandible basal half. (7) Scape as in *quadridentata*. (10) As in *hurdi* but slightly larger, deeper, more distinct. (13) Orbital convergence ratio as 1.68:1.24,1.36. (14) Galea finely pebbled (30×), shiny (to dull), tip narrowly rounded. Galeal gap to length of galea exposed beyond closed mandibles variable, 0.31:0.51(0.39:0.43). (15) Head width to head length as 2.50:1.84,1.36(2.40:1.62,1.48). (17) Eye length, mio, and flagellar length as 1.34:1.24:1.70. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.42:0.48:0.31:0.34. Interocellar less than ocellocular! (19) Ocellolabral greater than clypeal width, 1.48:1.19,1.24. (20) Clypeocellar to outer subantennal sutural as 0.90:0.77,1.18. (21) Flagellar length about 3.3 times length of scape, 1.70:0.56.

Mesosoma. (25) Scutal disc with punctures smaller than in *quadridentata,* larger than in *hurdi,* 0.5 pwa to contiguous, interspaces shiny, but scutum rather dull because of close, deep punctures (20×). (26) Dorsal enclosure of propodeum sharply declivous; pattern of ridges as in *hurdi;* median portion but little produced, length about 0.29, or 1.7 mow. (27) Same note as for *deserticola*. Foreleg colored like that of *pugionis*. (28) Middle leg colored like that of *hurdi;* lengths of tibia, basitarsus, and apicotarsus as 1.07:0.92:0.99, ratios which are almost identical with those of *hurdi*. (29) Hind leg with yellow on basitibial plate, irregular splotching along anterior surfaces of tibia and basitarsus, latter with black border. (30) Tegula brown without yellow patch. Humeral plate brown. (32) Marginal cell 6-9 and 3-4 both greater than 9-wt, 1.24:1.09:0.94.

Metasoma. (35) Tergum 1 with punctures of median area subequal (to slightly smaller) to those of scutum, intermediate in size between those of *kucalumea* and *hurdi,* contiguous, interspaces shiny.

Type Material. Holotype male and allotype female, from Coyotes, Durango, 8300 ft., Aug. 8, 1947 (C. D. Michener, David Rockefeller Expedition), are at the American Museum of Natural History, New York.

In addition four male and six female paratypes are from Mexican localities as follows: Atlacomulco (22 mi. N.), México, 8100 ft., 3 males, Aug. 18, 1954 (C. D. Michener and party); Durango (10 mi. W.), Durango, 1 female, July 12, 1954 (E. I. Schlinger); El Salto (6 mi. N.E.), Durango, 8500 ft., 1 female, Aug. 10, 1947 (M. A. Cazier, David Rockefeller Expedition); Fresnillo (9 mi. S.), Zacatecas, 1 male, Aug. 10, 1954 (E. G. Linsley, J. W. MacSwain, R. F. Smith), 1 female, same locality, Aug. 20, 1954 (J. W. MacSwain), on *Haplopappus gracilis;* Toluca (24.5 mi. N.W.), México, 1 female, July 30, 1962 (Naumann and Marston); Zacatlán (20.7 mi. N.W.), Puebla, 7950 ft., 2 females, Aug. 22, 1962 (University of Kansas Mexican Expeditions). Paratypes are at the University of California, Berkeley; the Snow Entomological Museum of The University of Kansas, Lawrence; the American Museum of Natural History, New York; and in the author's collection.

Subgenus VERBENAPIS Cockerell and Atkins

Verbenapis Cockerell and Atkins, 1902, Ann. Mag. Nat. Hist., (7) 10:44; Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric., Monogr. No. 2:1103.
Type species. Calliopsis verbenae Cockerell and Porter, 1899, monobasic.

This subgenus is closer to *Calliopsima* than to the others. As discussed under the genus, it has characters in common with *Hypomacrotera* and the South American *Liopoeum* and *Acamptopoeum*. The four species are interrelated, but *verbenae* and *micheneri* are close to each other as are *hirsutifrons* and *nebraskensis*. Depending upon what characteristics are chosen, any one may be thought of as somewhat singular with respect to the other three, a situation which precludes any definitive statement on their phylogeny at present. There are no records from Canada, nor from any southern state east of the Mississippi River. They are apparently oligolectic on *Verbena* flowers, and indeed are particularly adapted to collect pollen from them (see under bionomics of *nebraskensis*).

Verbenapis differs from the other subgenera as follows: propodeum with impunctate, shiny, unsculptured dorsal area bearing a median depression with a longitudinal, low ridge giving the impression of twin pits; posterior dorsal margin of the pronotum without pale maculation; front tarsi of females with rows of long, stout, curled hairs ventrally; male sternum 5 with posterior margin concave medially; sternum 6 with *rounded* lobes instead of pointed projections; areas of the male tergum 7 lateral to pygidial plate dropping sharply downward toward the median sagittal plane of the body and acting as a sheath for the enclosed genitalia.

FEMALE. Length, 6.4-8.8 mm. Integumental background color of head, mesosoma, and metasomal terga black, of metasomal sterna black to brown. Integument almost entirely shiny, non-metallic, rarely some roughening present.

Head. Cream colored areas: (1) paraocular area with a triangular patch in lower ventral corner; (2) clypeus, cream color variable in extent and less than in male; (3) labrum, usually labral plate only, absent on punctate apical portion; (4) absent on supraclypeal area except sometimes a tiny dot; (5) absent on subantennal plate, but indications of potential cream color in some

specimens; (6) mandible, basal portion. (7) Scape, pedicel, and flagellomeres 1-4 dark brown to black, upper surface of flagellum dark brown, lower surfaces of flagellomeres 5-10 tan. (8) Hair of vertex, frons, gena, and lateral angles of clypeus white, of disc of clypeus sometimes fulvous. (10) Punctures along ocellocular line medium-sized to very fine, interspaces smooth, moderately shiny; impunctate area lateral to posterior ocellus shiny; punctures of frons near middle of frontal line mixed tiny and large, interspaces smooth, moderately shiny. (11) Frontal line with lower portion a raised, narrow sulcus. (12) Clypeus with lower half of disc flattened or medially concave. Clypeus with a median subapical portion, usually transparent, overhanging the preapical groove from which arise long, amber hairs. (13) Inner orbits slightly convergent below. Facial fovea shallow, shiny, indistinctly sculptured (45×), elongate elliptical, upper limit slightly below level of middle ocellus, lower limit above level of upper rim of antennal socket. (14) Galea long, relatively slender; galeal gap absent or less than mow, length of galea exposed beyond closed mandibles usually extending to or beyond base of prementum. (15) Head width/head length 1.3-1.5. (17) Eye length less than mio, subequal to basal labial palpomere, equal to or less than flagellar length. (18) Interantennal greater than antennocular and more than twice diameter of antennal socket; antennocellar more than twice antennocular. (19) Ocellolabral equal to or greater than mio. (21) Basal labial palpomere 3.0-5.5 times length others combined. (22) Flagellomere 1 equal to or longer than flagellomere 9 (in *hirsutifrons* distinctly shorter). Flagellar length 2.3-2.5 times length of scape.

Mesosoma. (23) Light color absent along posterior dorsal border of pronotum. Some specimens with indistinct yellowish tan dash on medial apical rim of pronotum and similar dash at extreme posterolateral edge of pronotum. (24) Dorsum with hair white to fulvous, white elsewhere. (25) Scutal disc with punctures few, scattered, becoming larger, denser laterad, then abruptly smaller and denser along edges, interspaces shiny. (26) Dorsal enclosure of propodeum impunctate, shiny, unsculptured, bearing a median depression with a low, longitudinal ridge giving the impression of twin pits. (27) Foreleg with cream coloration. Front tarsus with suberect, thick, apically hooked hairs, amber basad, colorless apicad. Front mediotarsus with flattened, expanded tarsomeres each with a posteroventral prolongation. Front distitarsus strikingly different from other distitarsi: base laterally compressed, dorsal surface shiny, hairless, except for a few straight apical hairs. Tibial spurs white. (28) Middle leg with cream coloration; mediotarsus cylindrical. Hind leg dark; mediotarsus cylindrical. (30) Tegula and humeral plate without cream maculation (present in *micheneri*). (31) Wing colorless. Stigma testaceous to brown. (32) Marginal cell 6-9 subequal to longer than, and 3-4 shorter than 9-wt.

Metasoma. (34) Tergal hair bands white, band of tergum 1 often sparse or absent, of terga 2-4 always present. Suberect hair of discs of terga 4-5 long, white, usually moderately abundant. Prepygidial and pygidial fimbriae white, occasionally appearing pale fulvous because of enmeshed pollen or dust particles.

MALE. Length, 5.8-8.8 mm.

Head. Cream colored areas: (1) paraocular area a triangular patch in lower ventral corner; (2) clypeus, mostly to completely, with apical, narrow brown border; (3) labrum, on labral plate to entire impunctate basal portion, absent on punctate apical portion; (4) as in female; (5) absent on subantennal plate; (6) mandible basal fourth to two-thirds. (7) Scape, pedicel and flagellomeres as described for female but lighter. (8) As in female but more intensely fulvous where female has fulvous hair. (10) Punctures as described for female. (11) Frontal line with lower portion a carina with narrow, obsolete sulcus or none. (12) Clypeus as described for female. (13) Eyes bulging, inner orbits moderately to strongly convergent below. (14) Galea as in female. (15) Head width/head length 1.30-1.40. (17) Eye length variable with respect to mio and flagellar length. (20) Clypeocellar greater than outer subantennal sutural except subequal in *micheneri*. (21) Basal labial palpomere as in female. (22) Flagellomere 1 variable with respect to 9. Flagellar length 3.4-4.1 times length of scape.

Mesosoma. (23) As in female. (24) Dorsum with hair as in female. Scutellar and metanotal hair pads absent. (25) Scutal disc with punctures as in female except finer. (26) As in female. (27) Legs with white, cream, or yellowish coloration. Tibial spurs white. Foreleg with cream coloration on femoral apex and stripe along anterior aspect of tibia from knee apicad, interrupted subapically in *nebraskensis* and *micheneri*. (28) Middle leg with cream coloration at least on knee. Middle tibia with dorsoapical projection. (29) Hind leg without light coloration (except in *hirsutifrons*). Hind mediotarsus and distitarsus shorter than those of other legs. (30,31,32) As in female.

Metasoma. (34) As described for female but hair bands sparser. (36,37) Sternum 5 with posterior margin concave medially. Sternum 6 with a bilobed median portion. Sternum 8 with a long, slender, clublike median projection. (38) Sterna and genitalia as illustrated (Figs. 123-143).

CALLIOPSIS (VERBENAPIS) VERBENAE Cockerell and Porter

(Figs. 123-128; Map 8)

Calliopsis verbenae Cockerell and Porter, 1899, Ann. Mag. Nat. Hist., (7)4:412; Cockerell, 1906. Trans. Amer. Ent. Soc., 32:300; Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric., Monogr. No. 2:1103 (synonym of *hirsutifrons*).

Closest to *nebraskensis* and *micheneri*. The female is distinguished from *nebraskensis* by having the brown color of the basal half of mandible with at

most a tiny area of yellow at the extreme base; by the clear oval area on the sclerotized apical portion of sternum 7 being a fourth or more wider than width of median ocellus; by the front basitarsus being about 6 times longer than wide; and by the shape, vestiture, and punctation of metasomal terga 1-2. The male is distinguished from *nebraskensis* by the key characters; by the eye length being less than the clypeal width; by the clypeal length being more than the scape length; and by the sterna and genitalia as illustrated. The male is separated from *micheneri* by the key characters; by a higher ratio of head length to minimum interocular and to intertegular; by the outer subantennal sutural being distinctly less than the clypeocellar; and by the sterna and genitalia, as illustrated.

Female. Length, 8.5 mm; forewing length, 5.7 mm; hindwing length, 3.9 mm; clypeal length, 0.59 mm; scutal length, 1.32 mm.

Head. Cream colored areas: (1) paraocular area a triangular patch in lower corner below line originating at junction of outer subantennal suture and frontoclypeal suture and extending diagonally ending on orbit slightly below level of lower rim of antennal socket; (2) clypeus, apical half or less of median portion with a median dorsal rectangular or concave emargination (usually), cream color extending onto the posteriorly bent sides of clypeus; (3) labral plate; (4) absent on supraclypeal area; (6) mandible a tiny area, often absent, at extreme base. (10) Punctures of ocellar triangle and immediately posteriad, 1 pwa or less. Lower dark paraocular area with punctures distinct, subequal to those of subantennal plate, 1 pwa; of light area few, variable in size. (13) Orbital convergence ratio as 1.67:1.50,1.11. Lower median border of supraclypeal area elevated slightly above level of adjacent clypeus. (14) Galea unsculptured (to finely pebbled at 30×, especially apicad and basad); galeal gap absent, tip of galea in repose extending just beyond base of prementum. (15) Head width to head length as 2.55:1.84,1.39(1.30-1.41). (16) Eye width in profile about 2.5 times protrusion of clypeus beyond it. (17) Eye length, mio, and flagellar length as 1.36:1.50:1.36. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.48:0.53:0.34:0.44. (19) Ocellolabral subequal to clypeal width, 1.51:1.53. (20) Clypeocellar to outer subantennal sutural as 0.92:0.85,1.08. (21) Basal labial palpomere 3.8 (3.3-4.0) times length of others combined. (22) Flagellar length about 2.3 times length of scape, 1.36:0.60.

Mesosoma. (25) Scutal disc with punctures between anterior ends of parapsidal lines of variable size but mostly larger ones, 1-2 pwa. Punctures immediately below episternal scrobe oblong, 1 pwa or less; anterior to scrobe eccentric, less than 1 pwa to contiguous, on a very shiny ground. Punctures of propodeal flats round, very deep, smaller than mesepisternal punctures, larger than scutellar punctures, less than 1 pwa. (27) Legs with cream color the same as on face. Foreleg with cream color on knee. Hooked hairs of front

tarsus slenderest of the subgenus. Front basitarsus narrow, length/width from 5.5 to 6.5. Front and middle mediotarsi with lengths subequal and exceeding hind mediotarsi 0.56:0.56:0.53. Front distitarsus fifth shorter than middle distitarsus which is subequal to hind distitarsus. (28) Middle leg with cream color on knee. (30) Tegula transparent dark brown. Humeral plate lighter brown than tegula. (31) Stigma three times as long as wide. (32) Marginal cell 6-9 longer than, and 3-4 shorter than 9-wt, 1.26:1.02:1.14 (1.29:1.11:1.14).

Metasoma. (34) Hair bands of terga 1-3 dense, of tergum 4 sparser. (35) Tergum 1 with punctures of median area subequal to scutal punctures, 1-2 pwa, becoming scattered laterad and posteriad, but dense and regularly spaced anterolaterad, about 1 pwa, interspaces shiny. Declivity of tergum 1 sharply distinct from dorsal portion, shiny, punctures about 15 μ in diameter. Raised dorsal surface at anterior edge of posterior depressed margin of tergum 1 complete from side to side. (36) Tergum 2 with punctures of median area irregularly spaced, about 1 pwa, sparser and larger laterad. Tergum 2 without a median bulge. Pygidial plate with dark brown margin, either light tan or dark brown center, about one-fifth longer than basal width, sides forming about 45° angle, tip narrowly rounded. (37) Sternum 6 with large, oval median clear area in apical sclerotized plate, this area wider than long, 0.26-0.29 by 0.17-0.20, length of area 0.35-0.40 times length of sclerotized plate.

Male. Length, 7.0 mm; forewing length, 5.2 mm; hindwing length, 3.6 mm; clypeal length, 0.51 mm; scutal length, 1.33 mm.

Head. Cream colored areas: (1) paraocular area a triangular patch in lower corner below a line from a point about a third down on inner orbit to about midpoint of outer subantennal suture (or to vicinity of anterior tentorial pit); (2) clypeus except for a brown triangular area in dorsolateral corner below subantennal plate, apical border brown laterally, amber medially; (3) labrum; (4) absent on supraclypeal area; (6) mandible basal half (or more). (10) Punctures similar to female except light portions of paraocular area and clypeus well punctured. (13) Orbital convergence ratio as 1.53:1.24,1.22. (14) Galea with medial portion shiny, basal and apical portions roughened more distinctly than in female; galeal gap absent, tip of galea in repose extending slightly beyond base of prementum. (15) Head width to head length as 2.26:1.72,1.32. (17) Eye length, mio, and flagellar length as 1.21:1.24:1.73. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.43:0.46: 0.27:0.37. (19) Ocellolabral greater than clypeal width, 1.36:1.31,1.04. (20) Clypeocellar to outer subantennal sutural as 0.87:0.75,1.16. (22) Flagellar length about 3.7 times length of scape, 1.73:0.48.

Mesosoma. (25) Punctation as in female except scutal disc with punctures finer, shallower, and less dense than in female or in *nebraskensis*, 2 pwa

between anterior ends of parapsidal lines, mesepisternal punctures rounder. (27) Legs with light color in part different from that on face. Foreleg with yellowish stripe on tibia reaching apex; basitarsus and second tarsomere white on anterior surface, others straw color. (28) Middle leg with ventral apical rim of yellow on trochanter; yellow macula on dorsal surface of femoral apex and knee; basitarsus colored like that of foreleg, apicotarsus light tan, darker than that of foreleg; lengths of tibia, basitarsus, and apicotarsus as 1.00:0.68:0.82. (29) Hind leg colored like middle leg but without femoral and tibial light color (basitibial plate may bear indistinct yellow on basal half medially). (30) As in female. (31) Wing 12-13/13-14 about 5. Stigma about 5 times as long as wide. (32) Marginal cell 6-9 longer than, and 3-4 shorter than 9-wt, 1.12:0.97:1.07.

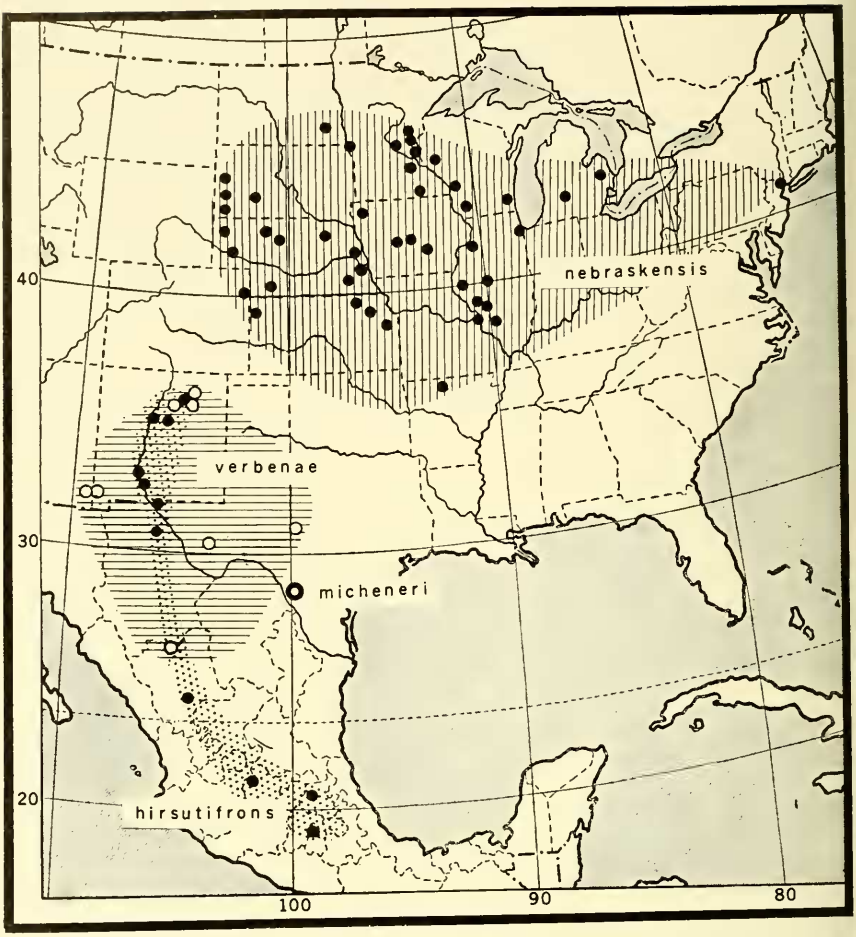
Metasoma. (34) Tergal hair bands as in female but sparser. (35) Tergum 1 with punctures of median area subequal to scutal punctures but deeper, evenly spaced on dorsum, about 1 pwa. Declivity of tergum 1 as in female except at least twice as many punctures, finer than on dorsum. Raised dorsal surface as in female. (36) Tergum 2 with punctures of median area finer than on 1, sparser, but fairly evenly distributed. Pygidial plate with dark brown (to black) flat margin, broadly rounded at tip.

Discussion. Too few specimens of this species are available to make meaningful statements on geographic variation, but the one Mexican female is conspicuously larger than the females from the United States. No data on the bionomics of the species have been published; Robertson's notes on *Verbenapis* actually pertained to *nebraskensis* (q.v.).

Type Material. The holotype female taken at Las Vegas, New Mexico, Aug. 9 (W. Porter), on *Verbena stricta,* has not been located. One male paratype, same collection data, is in the Academy of Natural Sciences of Philadelphia and two male paratypes, same data as above, one in the U. S. National Museum, one in the Museum of Comparative Zoology, Harvard University. The above description of the female is principally based on a specimen from Pecos, New Mexico, July 7 (T. D. A. Cockerell), on *Verbena bipinnatifida,* while that of the male is based on the first paratype listed above.

Distribution. Western Texas to southeastern Arizona and south to Durango, Mexico. It has been collected in Texas in April only, but elsewhere from July 7 to September 7.

In addition to the type material, 9 females and 2 males have been examined. The localities below include the type locality: Arizona: Portal (5 mi. W.), Chiricahua Mts., Aug. 24, 1958 (P. A. Opler). New Mexico: Ft. Union (2.4 mi. S.), Mora Co., July 9, 1959 (Ray F. Smith); Las Vegas, 3 males, 1 female, Aug. 9 (W. Porter), on *Verbena stricta,* and 1 male, same data, on *Sphaeralcea lobata;* Pecos, 1 female, July 7 (T. D. A. Cockerell), on *Verbena bipinnatifida;* Pecos, 1 male, 1 female, July 19 (Cockerell and Porter), on *Verbena macdougalli;* Rodeo (2.5 mi. N.), Hidalgo Co., Sept. 7, 1959 (D. D. Linsdale). Texas: Davis Mts., 1 female, April 17, 1954 (R. H. Beamer), on *Chamaesaracha conloides,* 1 female, same date (L. D. Beamer). Durango: El Tascate, 6400 ft., July 28, 1947 (C. D. Michener).



MAP 8. Map showing the known distributions of *Calliopsis (Verbenapis) hirsutifrons* Cockerell, *C. (V.) verbenae* Cockerell and Porter, *C. (V.) micheneri* Shinn, and *C. (V.) nebraskensis* Crawford.

CALLIOPSIS (VERBENAPIS) NEBRASKENSIS Crawford

(Figs. 129-133; Map 8)

Calliopsis verbenae var. *nebraskensis* Crawford, 1902, Canadian Ent., 34:240; Graenicher, 1910, Bull. Pub. Mus. Milwaukee, 1:238.

Calliopsis verbenae nebraskensis; Swenk and Cockerell, 1907, Ent. News, 18:179; Graenicher, 1935, Ann. Ent. Soc. Amer., 28:303.

Verbenapis verbenae; Robertson, 1914, Ent. News, 25:72; 1922, Psyche, 29:171; 1926, Ecology, 7:379; 1929, Flowers and Insects, pp. 10, 216-218; Robertson, Psyche 36:115-116; Pearson, Ecol. Monogr., 3:378. (misidentifications)

Calliopsis nebraskensis; Crawford, 1915, Proc. U.S. National Museum, 48:179; Cockerell, 1916, Ann. Mag. Nat. Hist., (8)17:279; Rau and Rau, 1916, Jour. Anim. Behav., 6:368; Stevens, 1919, Canadian Ent., 51:210; Cockerell, 1921, Amer. Mus. Nov., No. 24:14; Rau, 1922, Trans. Acad. Sci. St. Louis, 24:33; Cockerell, 1928, Univ. Colorado Studies, 16:103; Stevens,

1950, Bull. North Dakota Agric. Exp. Sta., 12:93; Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric., Monogr. No. 2:1103; Mitchell, 1960, North Carolina Agric. Exp. Sta. Tech. Bull., No. 141, vol. 1:288, 291-294.

Calliopsis sp.; Washburn, 1919, Minnesota Agric. Exp. Sta., Jour. series, Paper No. 156:229 (dorsal view of female).

Females differ from other *Verbenapis* in the shape and punctation of metasomal terga 1 and 2. Females are distinguished from *verbenae* by having the basal third to half of the mandible cream colored; by the clypeal width being subequal to the flagellar length; by the front basitarsus being about four times longer than wide; and by the finer punctation throughout. The male is distinguished from *verbenae* as discussed under that species; from *hirsutifrons,* with which it shows strong affinities based on similarities of facial structure and dimensions, by the key characters, by the lower ratio of head length to intertegular distance, by the flagellar length being subequal to the head length, by the higher value of wing ratio 12-13/13-14, and by the sterna and genitalia, as figured.

Female. Length, 7.5 mm; forewing length, 5.4 mm; hindwing length, 3.7 mm; clypeal length, 0.51 mm; scutal length, 1.33 mm.

Head. Cream colored areas: (1) paraocular area as in *verbenae* (triangular patch frequently truncated dorsally); (2) clypeus as in *verbenae* (upper median emargination of cream colored area may be absent, wedgeshaped, rectangular, evenly concave, or sinuous); (3,4) as in *verbenae;* (6) mandible, basal third. (10) Punctures as in *verbenae* except somewhat finer, less shiny. (13) Orbital convergence ratio as 1.58:1.36,1.16. Lower median border of supraclypeal area slightly below level of adjacent clypeus. (14) Galea unsculptured (30×), narrower and more sharply pointed than in *verbenae;* galeal gap absent, tip of galea in repose just extending to or beyond base of prementum. (15) Head width to head length as 2.43:1.70,1.43(1.36-1.44). (16) Eye width in profile 4.0(3.5-4.0) times protrusion of clypeus beyond it, clypeus more abruptly protuberant than *verbenae.* (17) Eye length, mio, and flagellar length as 1.31:1.36:1.34. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.46:0.46:0.34:0.37. (19) Ocellolabral greater than clypeal width, 1.43:1.36,1.05. (20) Clypeocellar to outer subantennal sutural as 0.92: 0.77,1.20. (21) Basal labial palpomere about 3.5 times length of others combined. (22) Flagellar length about 2.2 times length of scape, 1.34:0.61.

Mesosoma. (25) Scutal disc with punctures as in *verbenae* except finer and shallower. Punctures immediately below episternal scrobe round to ovate, 1 pwa or slightly more; anterior to scrobe as in *verbenae.* Punctures of propodeal flats as in *verbenae* except finer, mostly 1 pwa. (27) Legs with cream color the same as on face. Foreleg with cream color on knee. Front basitarsus broader and shorter than in *verbenae,* length/width from 3.5 to 4.0. Middle mediotarsus fifth its length longer than front mediotarsus, and tenth its length longer than hind mediotarsus. Front distitarsus about fourth shorter

than middle distitarsus, which is subequal to hind distitarsus. (28) Middle leg dark. (30) Tegula as in *verbenae*. Humeral plate lighter than tegula and lighter than in *verbenae*. (31) Stigma about 3.5 times as long as wide. (32) Marginal cell 6-9 longer than, and 3-4 shorter than (to subequal to) 9-wt, 1.21:0.97:0.99.

Metasoma. (34) Band of tergum 1 absent, of terga 2-3 present (but much sparser than in *verbenae*), of tergum 4 denser than on 3. (35) Tergum 1 with punctures of median area much finer than scutal punctures, 3-6 pwa, becoming scattered laterad and posteriad. Declivity of tergum 1 not sharply distinct from dorsal portion, shiny, punctures ultra fine, less than 10 μ in diameter. Raised dorsal surface at anterior edge of posterior depressed margin of tergum 1 absent medially, entire median portion sloping anteriorly downward with central portion concave. (36) Tergum 2 with punctures of median area dense, regularly spaced, 1-2 pwa, punctures scattered laterad. Tergum 2 with median area a gently sloping bulge. Pygidial plate similar to *verbenae* but sides forming a smaller angle, about 40°, and tip more narrowly rounded. (37) Sternum 6 with tiny, round median clear area in apical sclerotized plate, diameter 0.09-0.12, length of area about 0.20-0.33 length of sclerotized plate.

Male. Length, 7.0 mm; forewing length, 5.2 mm; hindwing length, 3.6 mm; clypeal length, 0.48 mm; scutal length, 1.41 mm.

Head. Cream colored areas: (1,2,4) as in *verbenae;* (3) labrum except brown in dorsolateral corners (frequently entire basal half); (6) mandible basal third only. (10) Punctures coarser, more abundant, and more regularly spaced than in female or in *verbenae;* punctures below middle ocellus larger, much denser than in *verbenae,* 1 pwa or less, subequal in size to those of subantennal plate. (13) Orbital convergence ratio as 1.60:1.12,1.42. (14) Galea shiny, unsculptured (30×), but with barely detectable sculpture at 45×; galeal gap absent, tip of galea in repose extending slightly beyond base of prementum. (15) Head width to head length as 2.33:1.72,1.36. (17) Eye length, mio, and flagellar length as 1.22:1.12:1.80. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.43:0.46:0.26:0.32. (19) Ocellolabral greater than clypeal width, 1.36:1.19,1.14. (20) Clypeocellar to outer subantennal sutural as 0.88:0.71,1.24. (22) Flagellar length about 3.5 times length of scape, 1.80:0.51.

Mesosoma. (25) Punctation as in female except scutal disc with punctures larger, denser than in either female or *verbenae,* 1 pwa or less between anterior ends of parapsidal lines, punctures immediately below episternal scrobe about 2 pwa. Punctures of propodeal flats finer than in *verbenae,* 1 pwa or more. (27) Legs with light color in part different from that on face. Foreleg with yellow stripe on tibia interrupted preapically; basitarsus pale whitish on anterior aspect, apicotarsus straw color. (28) Middle leg with only faint indication of yellow on dorsal surface of femoral apex and with (or

without) light color on knee; basitarsus pale amber to light brown, apicotarsus light brown; lengths of tibia, basitarsus and apicotarsus as 0.94:0.73:0.75. (29) Hind leg entirely light brown. (30) As in female. (31) Wing 12-13/13-14 about 10. Stigma about 4 times as long as wide. (32) Marginal cell 6-9 and 3-4 longer than 9-wt, 1.16:0.99:0.94.

Metasoma. (34) Hair bands of terga 1 and 4 obsolete, of terga 2-3 very sparse. Suberect hair of disc of tergum 5 shorter than in *verbenae*. (35) Tergum 1 with punctures of median area extremely fine, about third of diameter of scutal punctures, evenly spaced on dorsum, 3 pwa. Declivity of tergum 1 similar to female. (36) Tergum 2 with punctures of median area larger than on tergum 1. Pygidial plate with black upturned margin, narrowly rounded at tip. (38) Penis longer in comparison to penis valve than in *verbenae*.

Type Material. Holotype female, U. S. N. M. No. 5237, from Lincoln, Nebraska, July 7, 1901 (J. C. Crawford, No. 427), on *Verbena*, one female paratype, same data except Aug. 4, 1901 (No. 527) and two male paratypes, same data as holotype but Crawford No. 425 on one, no Crawford No. on the other, are at the U. S. National Museum. One male paratype, same data as holotype except Crawford No. 420, is at the Academy of Natural Sciences of Philadelphia, and one male paratype, same data as holotype except Crawford No. 423, is at the University of California, Riverside. Description of the female is principally based on the female paratype specimen listed above, while that of the male is based on the Crawford paratype No. 420.

Distribution. North Dakota south to Colorado and Kansas, east to Arkansas and northeast following the Prairie Peninsula and Great Lake states (if the range is continuous) all the way to northern New Jersey.

In addition to the type material, 150 males and 65 females were examined from the following localities which include the type: Arkansas: Marion Co. Colorado: Wray, 3700 ft. Illinois: Adams Co.; Carlinville; Chicago; Grafton; Havana; Havana, Devil's Hole; Meredosia (Sand Pit); Moline. Iowa: Ames; Boone (13 mi. N.W.); Gilbert (4 mi. E).; Iowa Co.; Johnson Co.; Sioux City. Kansas: Baldwin; Douglas Co.; Lawrence; Linn; Washington Co.; Riley Co.; Sherman Co. Michigan: Ionia Co.; Lapeer Co. Minnesota: Browns Valley; Fridley Sand Dunes, Anoka Co.; Hennepin Co.; Princeton; Sargents Bluff; Sucker Lake, Ramsey Co. Missouri: St. Louis. Nebraska: Halsey; Hamlet; Lincoln; Louisville; Monroe Canon, Sioux Co.; Neligh; Northport (2 mi. E.); Omaha; Valentine (27 mi. S.), Cherry Co. New Jersey: Closter, Bergen Co. North Dakota: Valley City. South Dakota: Hot Springs; Philip; Rapid Canyon; Whitewood. Wisconsin: Genoa, Vernon Co.; Maiden Rock, Pierce Co.; Milwaukee Co.; Prescott, Pierce Co.; Rutledge, Grant Co.; Waukesha Co.; Wyalusing, Grant Co.

Remarks. The specimens at hand are homogeneous for obvious external characters. Although specimens from North Dakota and Minnesota are larger than those from more southern localities, the difference is not statistically significant. The easternmost specimens, from northeastern New Jersey, differ from others in the combination of piceous integument and darker colors in all areas; more deeply fulvous hair of vertex, thoracic dorsum and abdominal bands; and smaller head length and abdominal width despite an

average length hindwing. The affinities of *nebraskensis* seem to be mostly with *verbenae*, yet the striking similarity in facial dimensions and ratios which groups *nebraskensis* with *hirsutifrons* and *verbenae* with *micheneri* suggests that *nebraskensis* is not a lineal descendant from either *verbenae* or *hirsutifrons*, and that its ancestor is some extinct or uncollected form.

BIONOMICS. Most of the flower records are for *Verbena* species; one each for *Ambrosia* and *Asclepias* are probably accidental. I have seen mixed pollen loads which incorporated pollen of Verbenaceae and Leguminosae. Robertson regarded this species as oligolectic on *Verbena* spp. and (1914) described the action of the females in obtaining pollen of *Verbena:* "Anthers of *Verbena* are included in a slender tube and above them is a circle of hairs. . . . Ordinary bees can only collect pollen which adheres to their tongues. *Verbenapis verbenae* [misidentification for *nebraskensis*] has its front tarsi provided with curled bristles. When collecting pollen the bee thrusts both front legs into the tube of the corolla and drags out the pollen with its front tarsi." Examination of specimens supports this observation, for pollen was often found packed between the curled hairs of the front tarsi. Robertson (1929) records the species at Carlinville, Illinois, as active from June 28 to September 11 which gives the flight period of the bee as 75 days, or well within the period of anthesis of *Verbena* from May 22 to October 5. Both sexes were taken by Robertson (1922) on *Verbena hastata, V. stricta,* and *V. urticifolia* (*in copulo* on the last two).

Robertson *(op. cit.)* found *Calliopsis (Calliopsis) andreniformis* visiting *Verbenaceae*, too: *Lippia lanceolata* and *Verbena bracteosa*, neither of which were visited by *nebraskensis*. At Lawrence, Kansas, *C. andreniformis* males visit *Verbena* sp., and at Nacogdoches, Texas, *Verbena tenuisecta,* but I have not seen females at *Verbena* at either locality.

Rau and Rau (1916) and Rau (1922) give notes on the nesting of *nebraskensis* at St. Louis, Missouri; it is similar to that of *andreniformis*. Hard-packed bare soil is selected for nest construction, e.g., a baseball diamond! A burrow is dug with a single or double entrance, in the latter case, the openings about two inches apart, and kept covered by a mound of "fine dust." Mating was quietly effected on the ground and copulation lasted perhaps five minutes. The same sort of buzzing, tumbling, and whirling in small circles by pairs on the dusty ground was seen for *nebraskensis* as I have seen with pairs of male *andreniformis*. Cockerell has observed similar behavior by males of *Nomadopsis zebrata* and mating pairs of *Calliopsis coloratipes*, and Rozen (1958) has noted it for *Nomadopsis a. anthidius* and *N. micheneri*. In the last instance, Rozen found mating pairs rather than males alone. The Raus state that this tumbling did not immediately precede or follow mating, but they were not able to catch pairs to determine sexes. *Sphecodes* spp. enter the burrows freely and are suspect, but unproven, parasites. *Schecodes*

brachycephalus Mitchell and *Sphecodes* sp. are discussed as possible parasites of *Calliopsis andreniformis* in the section on the biology of that species.

Flower Records. Literature and label records include *Ambrosia* and *Asclepias,* both of which are probably accidental, *Medicago sativa, Verbena hastata, V. stricta, V. urticifolia, Vernonia.*

CALLIOPSIS (VERBENAPIS) HIRSUTIFRONS Cockerell

(Figs. 134-138; Map 8)

Calliopsis hirsutifrons Cockerell, 1896, Canad. Ent., 28:158; 1897, Bull. Univ. New Mexico, 24:19; Michener, 1951, *in* Muesebeck *et al.,* U.S. Dept. Agric., Monogr. No. 2:1103.

Readily distinguished from other *Verbenapis* by the small size. It is closest to *nebraskensis* on the basis of numerous head dimensions and ratios as well as the nature of the clear, median disc of the metasomal sternum 6 of the female.

It has a punctation pattern similar to that of *verbenae* and *micheneri,* and the shape of the metasomal terga is closer to them than to *nebraskensis.* The concave nature of the medial basal margin of metasomal sternum 8 distinguishes the male from other *Verbenapis.* In the female the first labial palpomere is a fourth to a third shorter than the flagellar length, but in the other species it is subequal to or up to a third longer than the flagellar length. The female differs from *nebraskensis* in having the base of the middle tibia yellow, and from *verbenae* in the more extensive cream colored area on the mandible, and from both in the shape of the clypeal cream colored area as described in (2) below.

Female. Length, 6.5 mm; forewing length, 4.5 mm; hindwing length, 3.1 mm; clypeal length, 0.44 mm; scutal length, 1.19 mm.

Head. Cream colored areas: (1) paraocular area similar to *verbenae* and *nebraskensis* but dorsal apex of triangular patch ends at or above level of lower rim of antennal socket (may reach to level of lower border of facial fovea); (2) clypeus, the median portion of cream colored area produced dorsally to within half mow of frontoclypeal suture, the lateral portion extended to within less than 1 mow of anterior articulation of mandible; (3) labrum entirely or labral plate only; (4) absent on supraclypeal area (small dot may occur in impunctate lower median part adjacent to frontoclypeal suture); (6) mandible basal fourth. (10) Punctures of ocellar triangle fine, distinct, 1 pwa or more; punctures immediately posteriad larger, less than 1 pwa. (13) Orbital convergence ratio as 1.39:1.22,1.14. Lower median border of supraclypeal area at same level as adjacent clypeus. (14) Galea unsculptured; galeal gap subequal to mow. (15) Head width to head length as 2.14: 1.53,1.40(1.39-1.45). (16) Eye width in profile about 6.5 times protrusion of clypeus beyond it. (17) Eye length, mio, and flagellar length as 1.14:1.22:1.24.

(18) Interocellar, ocellocular, antennocular, and interantennal as 0.41:0.39: 0.32:0.36. (19) Ocellolabral greater than clypeal width, 1.29:1.19,1.08. (20) Clypeocellar to outer subantennal sutural as 0.85:0.65,1.31. (21) Basal labial palpomere about 3.2 times length of others combined. (22) Flagellar length about 2.4 times length of scape, 1.24:0.51.

Mesosoma. (25) Scutal disc with punctures between anterior ends of parapsidal lines distinct, mostly large, about 1 pwa. Punctures immediately below episternal scrobe deep, round, 1 pwa; anterior to scrobe, round, less than 1 pwa. Punctures of propodeal flats as in *verbenae* but finer, less than 1 pwa. (27) Legs with cream color the same as on face. Foreleg with cream color on knee. Front basitarsus long, narrow, length/width about 8.0 to 9.4. Front, middle, and hind mediotarsi as in *nebraskensis*. Front distitarsus third shorter than middle distitarsus which is subequal to hind distitarsus. (28,30) As in *verbenae*. (31) Stigma about 3 times as long as wide. (32) Marginal cell 6-9 longer than, and 3-4 shorter than 9-wt, 1.02:0.82:0.87.

Metasoma. (34) Bands of terga 1-4 quite dense, least so on tergum 1. (35,36) Tergal punctures finer than in *verbenae*, tergum 1 with punctures of median area more scattered, but punctation pattern similar. Pygidial plate similar to *nebraskensis*. (37) Sternum 6 with round, median clear area in apical sclerotized plate, diameter of area less than mow (about 0.15:0.17), and about third of length of sclerotized plate.

Male. Length, 6.0 mm; forewing length, 4.3 mm; hindwing length, 2.9 mm; clypeal length, 0.41 mm; scutal length, 1.10 mm.

Head. Cream colored areas: (1,3) As in *verbenae;* (2) clypeus except for narrow dark strip below subantennal plate; (4) supraclypeal area, a medial round spot touching frontoclypeal suture; (6) mandible basal third. (10) Punctures similar to those of female but different in manner described for male *verbenae*. (13) Orbital convergence ratio as 1.36:0.97,1.40. (14) As in female. (15) Head width to head length as 1.99:1.43,1.40. (17) Eye length, mio, and flagellar length as 1.02:0.97:1.72. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.36:0.41:0.20:0.32. (19) Ocellolabral greater than clypeal width, 1.17:0.97,1.21. (20) Clypeocellar to outer subantennal sutural as 0.77:0.61,1.25. (22) Flagellar length about 4.0 times length of scape, 1.72:0.43.

Mesosoma. (25) Punctation as in female. (27) Legs with light color in part different from that on face. Foreleg as in *verbenae*. (28) Middle leg colored like *verbenae* but tip of tibia cream colored, and apicotarsus dark brown. (29) Hind leg as in *verbenae* except apicotarsus dark brown. (30) As in female. (31) Wing 12-13/13-14 about 8.5. Stigma about 3.5 times as long as wide. (32) Marginal cell 6-9 and 3-4 longer than 9-wt, 0.94:0.85:0.80.

Metasoma. (34) Hair bands of terga 1-3 distinct, sparse medially, of tergum 4 obsolete. Suberect hair of disc of tergum 5 shorter than in *verbenae*.

(35) Tergum 1 with punctures of median area larger and deeper than scutal punctures, evenly spaced on dorsum, 1-2 pwa. Declivity of tergum 1 similar to female. (36) Tergum 2 with punctures of median area as in *verbenae*. Pygidial plate usually darker peripherally with an irregular submarginal line of coarse, oblong punctures.

Type Material. Holotype male, U. S. N. M. No. 5821, from Albuquerque, New Mexico, middle Aug., 1895 (T. D. A. Cockerell, No. 4527), is at the U. S. National Museum. The description of the female is principally based on a specimen from Garfield, New Mexico, July 16, 1952 (R. H. and L. D. Beamer, W. E. La Berge, and Cheng Liang), while that of the male is based on a specimen from Hot Springs, New Mexico, July 22, 1950 (R. H. Beamer).

Distribution. North central New Mexico, east of the Rio Grande River, to El Paso, Texas, south across the Mexican desert to the state of México.

In addition to the type material, 24 males and 9 females have been examined from the localities listed below which include the type: New Mexico: Albuquerque, middle Aug.; Garfield, July 16; Hot Springs, July 22; Moriarty, June 24; Radium Springs, July 16. Texas: El Paso, July 11. Chihuahua: Villa Ahumada, 5700 ft., July 28. Durango: San Juan del Rio, 5200 ft., July 30. Guanajuato: León (1 mi. N.W.), Aug. 9. Hidalgo: Ixmiquilpan, 5200 ft., July 29; Lagunilla, June 14. Mexico: Tepexpán, 6500 ft., Aug. 12.

Remarks. A female specimen from León, Guanajuato, has clypeus with only a lateral cream spot, labrum and mandible completely brown. A male specimen from San Juan del Rio, Durango, is the largest specimen and exhibits other differences in structure that may indicate a population worthy of subspecific recognition. Unfortunately the sterna and genitalia are not in good enough condition to make positive statements. The genital capsule is flatter, penis valve rather broader distally, volsella more sharply pointed, and penis slightly shorter in comparison to the penis valve than in other specimens. No biological data are available for the species.

CALLIOPSIS (VERBENAPIS) MICHENERI, new species

(Figs. 139-143; Map 8)

This large, distinctive species is named in honor of Dr. Charles D. Michener who discovered it and who has done much to aid in the present understanding of this genus. The species is distinguished from others of the subgenus by the occurrence of a triangular area of opaque cream coloration on the outer apical half of the tegula and by the high ratio of the first labial palpomere to the length of the others combined, usually about 5. The female is separated from *verbenae* by having finer punctures with wider interspaces, and by the basal outer half of the mandible being cream colored. The male is readily known by the large size and the pointed, narrow pygidial plate.

Female. Length, 8.3 mm; forewing length, 6.0 mm; hindwing length, 4.1 mm; clypeal length, 0.53 mm; scutal length, 1.44 mm.

Head. Cream colored areas: (1) paraocular area as in *hirsutifrons* but

triangle less extensive, ending dorsally at (or slightly above) level of upper portion of frontoclypeal suture, well below level of lower rim of antennal socket; (2) clypeus as in *hirsutifrons* except lateral cream color extends to within half (or more) mow of anterior articulation of mandible; (3,4) as in *hirsutifrons;* (6) mandible basal half (to third). (10) Punctation similar to *verbenae* but finer. Lower dark paraocular area with punctures distinct, finer than those of subantennal plate, 2-3 pwa. (13) Orbital convergence ratio as 1.60:1.41,1.13. Lower median border of supraclypeal area below level of adjacent clypeus. (14) Galea finely, distinctly pebbled on entire anterior surface (30×); galeal gap absent, tip of galea in repose extending slightly beyond base of prementum. (15) Head width to head length as 2.47:1.80,1.37(1.34-1.37). (16) Eye width in profile about 2.5 times protrusion of clypeus beyond it. (17) Eye length, mio, and flagellar length as 1.34:1.44:1.33. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.44:0.46:0.32:0.44. (19) Ocellolabral less than clypeal width, 1.46:1.53,0.96. (20) Clypeocellar to outer subantennal sutural as 0.94:0.82,1.14. (21) Basal labial palpomere 3.5 (3.5-5.5) times length of others combined. (22) Flagellar length about 2.3 times length of scape, 1.33:0.58.

Mesosoma. (25) Scutal disc with punctures between anterior ends of parapsidal lines uniform, fine, 2 pwa. Punctures immediately below episternal scrobe round, 1.5-2.5 pwa; anterior to scrobe round, 1 pwa. Punctures of propodeal flats round, finer than in others of the subgenus, subequal in size to scutal punctures, about 2 pwa. (27) Legs with light color the same as on face. Foreleg colored as in *hirsutifrons*. Front, middle, and hind mediotarsi and distitarsi as in *verbenae*. (28) As in *verbenae*. (30) Tegula transparent smoky tan with anterior patch of opaque cream coloration; humeral plate with anterior half cream colored, posterior half brown. (31) Stigma about 4 times as long as wide. (32) Marginal cell 6-9 longer than, and 3-4 shorter than 9-wt, 1.22:0.94:1.19.

Metasoma. (34) About as in *verbenae*. (35) Tergum 1 with punctures of median area almost as fine as in *hirsutifrons,* diameter subequal to scutellar punctures, tergum generously covered including posterolateral areas, punctures 1-3 pwa. (36) Tergum 2 with punctures of median area as in *verbenae* but 1-2 pwa anteromedially. Pygidial plate similar to *hirsutifrons* but more slender. (37) Sternum 6 with oval, median clear area in apical sclerotized plate, this area wider than mow, wider than long, about 0.24:0.19, and about third of length of sclerotized plate.

Male. Length, 8.8 mm; forewing length, 6.1 mm; hindwing length, 4.1 mm; clypeal length, 0.60 mm; scutal length, 1.59 mm.

Head. Cream colored areas: (1,2,3,4) as in *hirsutifrons;* (6) mandible as in *nebraskensis*. (10) Punctures similar to those of female but different in the manner as described for *verbenae*. (13) Orbital convergence ratio as 1.77:1.48,

1.19. (14) Galea lightly, distinctly roughened as in female; galeal gap absent, tip of galea in repose extending beyond base of prementum by length of second labial palpomere (or more). (15) Head width to head length as 2.70: 2.01,1.35. (17) Eye length, mio, and flagellar length as 1.45:1.48:1.87. (18) Interocellar, ocellocular, antennocular, and interantennal as 0.49:0.49:0.32:0.48. (19) Ocellolabral less than clypeal width, 1.36:1.58,0.86. (20) Clypeocellar subequal to outer subantennal sutural, 0.94:0.95. (22) Flagellar length about 3.6 times length of scape, 1.87:0.53.

Mesosoma. (25) Punctation as in female. (27) Legs with light color the same as on face except tibial stripe yellowish. Foreleg with color as in *nebraskensis* except trochanter as in *verbenae,* knee cream colored, tarsus brown. (28) Middle leg with trochanter as in *verbenae,* knee cream colored, tarsus brown. (29) In a few specimens, hind leg with medial portion of basitibial plate whitish with black (to dark brown) border. (30) As in female. (31) Wing 12-13/13-14 about 5.5. Stigma about 5 times as long as wide. (32) Marginal cell 6-9 longer than, and 3-4 shorter than 9-wt, 1.26:1.00:1.17.

Metasoma. (34) Hairiest of the subgenus. Hair bands of terga 1-4 distinct, sparse. Suberect hair of disc of tergum 5 denser and much longer than other species in the subgenus. (35) Tergum 1 with punctures of median area subequal to scutal punctures, deeper and finer than in *hirsutifrons* or *verbenae,* 1-2 pwa. Declivity of tergum 1 similar to female. (36) Tergum 2 with punctures of median area as described for *verbenae.* Pygidial plate twice as long as broad at base with extremely narrow, black, slightly upturned border; sides forming 25° (to 30°) angle, tip very narrowly rounded. (37) Medial lobes of sternum 6 separated by a deep cleft, depth about twice (or more) width of one lobe. (38) Penis valve rounded at apex with distinct subapical pointed protuberance.

Type Material. Holotype male and allotype female from Carrizo Springs, Dimmit Co., Texas, April 14, 1949 (C. D. Michener and R. H. Beamer), on *Verbena cloveri,* are in the Snow Entomological Museum of The University of Kansas, Lawrence. Two female and 25 male paratypes bear the same collection data; two male paratypes, same locality, were taken March 28, 1946, by C. D. Michener who informs me that they were visiting the same species of *Verbena.*

Remarks. Known only from the type locality in Texas. Its host flower is endemic to Texas.

NOMEN NUDUM in CALLIOPSIS

CALLIOPSIS BRIDWELLI Bridwell

Calliopsis bridwelli Bridwell, 1899, Trans. Kansas Acad. Sci., 16:210.

This name was published in a list of insects of Kansas and must represent a misidentification of a common species.

NOMEN DUBIUM in CALLIOPSIS

CALLIOPSIS FLAVIFRONS Smith

Calliopsis flavifrons Smith, 1853, Catalogue of Hymenoptera in the British Museum, 1:129, male; Cresson, 1887, Trans. Amer. Ent. Soc. Suppl. :245; Cockerell, 1897, Bull. Univ. New Mexico, 24:26; 1898, Trans. Amer. Ent. Soc., 25:197; 1905, Trans. Amer. Ent. Soc., 31:321, female; Sandhouse, 1943, Proc. U.S. Nat. Mus., 92:531 (=*Camptopoeum prinii* Holmberg, 1884) (misidentification); Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric., Monogr. No. 2:1103; Mitchell, 1960, North Carolina Agric. Exp. Sta. Tech. Bull. No. 141:293.

Smith's description of the male is given below.

"Male. Length 4 lines [=8.47 mm]. Black, the face, *scape of the antennae in front**, labrum and mandibles yellow, the latter have a black line on their inferior margin and are ferruginous at the tips; the flagellum pale testaceous beneath. Thorax, the disk thinly covered** with pale ochraceous pubescence; the anterior and intermediate tibiae in front yellow; all the tibiae and tarsi have a pale glittering pubescence; the apical joints of the tarsi ferruginous; wings subhyaline, iridescent, nervures fuscous, the tegulae testaceous. Abdomen short and somewhat globose, delicately punctured, the margins of the segments have on each side a short fascia of white pubescence.

"Obs. The fascia on the abdomen probably in very recently disclosed specimens would be entire. Hab. East Florida. Coll. of F. Smith. [Collector E. Doubleday, Esq.]"

Cockerell (1905) described a female in the British museum collection bearing the *flavifrons* type label. The specimen he described was undoubtedly *C. andreniformis* Smith. The difference in sex shows that he did not have *flavifrons* before him.

At least three thoroughly competent bee specialists (Cockerell, Mitchell, and Moure) have failed to find the type of this species in the British Museum or among the Smith types at the Hope Museum in Oxford.

The original description is inadequate to determine the species, and *flavifrons* must remain a *nomen dubium*.

Species erroneously assigned to CALLIOPSIS

Perhaps a score of species occurring outside the United States and Canada have been described as *Calliopsis*. All but two have subsequently been transferred to other genera, mostly to related panurgine genera. The following two species are here asisgned their proper genera.

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* When compared to Smith's description of *Calliopsis flavipes* this character is a clue that Smith described either the form of *C. coloradensis* Cresson from the southeastern United States, or an exceptional specimen of *Acamptopoeum* accidently introduced to Florida by man. Italics mine.

** The disc of the thorax is *thinly* covered with pale ochreous pubescence in the specimens of *C. coloradensis* from the southeastern United States but all known species of *Acamptopoeum* have the disc of the thorax densely covered.

I am indebted to Padre J. S. Moure, as mentioned elsewhere, for his notes and measurements on the first species, and also for advising me of the correct placement of the second species based on his examination of the type specimen.

ACAMPTOPOEUM MACULATUM (Smith) new combination

(Map 1)

Calliopsis maculatus Smith, 1853, Catalogue of Hymenoptera in the British Museum, 1:129, male; Cockerell, 1889, Trans. Amer. Ent. Soc., 25:196; Cockerell, 1901, Ann. Mag. Nat. Hist., (7)7:129 (transferred to *Spinoliella*); Cockerell, 1905, Trans. Amer. Ent. Soc., 31:321, female; Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agric., Monogr. No. 2:1103; Mitchell, 1960, North Carolina Agric. Exp. Sta. Tech. Bull. No. 141:293.

The description of the female type by Smith is given below.

"Female. Length 4 lines [=8.47 mm.]. Black, the sides of the clypeus, a coronet-shaped spot above, on each side of it a minute lunate spot, and another at the base of the mandibles, yellow; the flagellum fulvo-testaceous beneath. Thorax, the disk has a fulvous pubescence, on the metathorax and beneath it is a griseous; the wings hyaline, iridescent, their apical margins having a slight fuscous cloud, the tegulae testaceous; the tibiae and tarsi above have a glittering pale yellow pubescence, on the tarsi beneath it is bright fulvous, the claw-joints ferruginous; the calcariae [tibial spurs] ferruginous, the extreme base of the anterior and intermediate tibiae yellow. Abdomen ovate, the margins of the segments narrowly testaceous, and having a marginal fascia of pale ochraceous pubescence, on the two basal segments usually nearly obliterated. Hab. East Florida. Coll. of F. Smith." [Collected by Edward Doubleday, Esq., in 1838.]

Supplementary description and measurements by Professors Padre J. S. Moure, T. B. Mitchell (1960), and Charles D. Michener (1965) are given below.

Female. Length, 9.2 mm; forewing length, 7.4 mm; clypeal length, 0.65 mm.

Head. Yellow areas: (1) paraocular area a very small mark in lowermost corner and short, very narrow stripe adjacent to frontoclypeal suture running ventrolaterad from anterior tentorial pit; (2) clypeus on each side laterad from labral notch, dividing it about equally into thirds, middle third black; (3) absent on labrum; (4) supraclypeal area a spot; (5) subantennal plate a small spot; (6) mandible a basal spot. (7) Scape and pedicel black; flagellomere 1 with a vague yellowish mark on ventral (frontal) surface. (10) Punctures of frons and gena exceedingly minute, barely visible (30×), interspaces shiny; (11) Frontal line with lower portion a sharp raised carina. (12a)

Clypeus with punctures of disc deep, distinct, close, interspaces shiny. (12b)* Labrum with area basad from high premarginal carina punctate, area apicad to carina smooth, shiny, impunctate. (13a)* Inner orbits only slightly convergent below, orbital convergence ratio as 2.02:1.97,1.03. (13b) Facial fovea shallow, broad medially, narrowed almost to acute angle above and below. (15) Head width to head length as 3.20:2.18,1.47; abdominal width 3.25. (17)* Eye length, mio, and flagellar length as 1.60:1.97:1.76. (18) Interocellar, ocellocular, antennocular, interantennal, and antennocellar as 0.51:0.61:0.54: 0.44:0.71. Antennocular subequal to width of eye in frontal view. (19)* Ocellolabral shorter than clypeal width, 1.73:1.98,0.87. (20) Clypeocellar to outer subantennal sutural as 1.09:0.44,2.46. Outer subantennal sutural:inner subantennal sutural:width of subantennal plate as 0.44:0.22:0:31. Clypeal length 0.65. (22) Lengths of flagellomeres 1-4 and 10 as 0.20:0.14:0.16:0.16: 0.31. Flagellar width less than mow, 0.20:0.22. *Flagellar length about 2.1 times length of scape, 1.76:0.84.

Mesosoma. (23) Light areas absent. (24) Hair of dorsum abundant, rather short, and whitish. (25) Scutal and scutellar punctures very fine, close, deep and distinct, interspaces shiny. (26) Dorsal enclosure of propodeum slightly longer than mow, 0.26:0.22, surface unsculptured, not excavated, highly polished. (27) Foreleg with yellow spot on distal end of femur and base of tibia. (28) Middle leg with two yellow spots on femur and one at base of tibia. Lengths of tibia, basitarsus, and spur as 1.43:1.12:1.12 (spur as long as basitarsus!). Spur with several coarse teeth on apical two-thirds. (29) Hind leg dark. (31) Stigma 4.33 times as long as broad (includes costal vein), 0.88:0.20. (32) Marginal cell 6-9 4 times as long as broad, 1.73:0.43, and greatly exceeding 9-wt, 1.31. Prestigmal length 5-2,0.34. Wing 10-11/11-14 as 1.00:1.14; 11-12/13-14 as 0.22:0.14. Hindwing with 11 hamuli.

Metasoma. (34) Suberect hair of disc of tergum 5 dark in part. (35,36) Terga 1 and 2 with punctures of median area minute, close, interspaces shiny.

Type Material. Holotype female, No. 17.a.1800, from East Florida, collected by E. Doubleday in 1838, is in the British Museum (Natural History).

Distribution. If this specimen was really captured in East Florida, it is presumably because it had been recently introduced there by man's activities. No other specimens of *Acamptopoeum* have ever been taken north of Colombia, South America.

Discussion. The specimen is unquestionably a panurgine bee closely related to *Calliopsis,* and the list below summarizes certain key characteristics found in *maculatum* as to their occurrence in species of the listed genera and constitutes the evidence for my transfer of *maculatum* to the genus *Acamptopoeum*. The numbers refer to characters indicated in the description above;

* Measurements kindly made by Prof. Charles D. Michener, July 1965.

+ means that the character of *maculatum* occurs in the genus; — means that the character does not occur in the genus.

Number	*Calliopsis*	*Acamptopoeum*	*Hypomacrotera*	*Liopoeum*
1	—	+	+	—
2	+	+	—	—
10	—	+	+	—
11	—	+	—	—
12b	—	+	—	—
13b	—	+	—	—
24	—	+	—	—
28	—	+	—	—

Items 12b and 28 seem absolutely diagnostic for *Acamptopoeum*. Item 28 shows a mesotibial spur as long as the middle basitarsus and coarsely toothed on the apical two-thirds. In *Calliopsis* only *squamifera* has a spur almost as long as the basitarsus, and it is completely bare (30×).

BICOLLETES SPEGAZZINI (Jorgensen) new combination

Calliopsis spegazzini Jörgensen, 1912, Zool. Jahrb., Syst., 32:121.

Padre J. S. Moure has determined the correct generic assignment from an examination of the type specimen.

BIOLOGY AND ECOLOGY OF *CALLIOPSIS ANDRENIFORMIS*

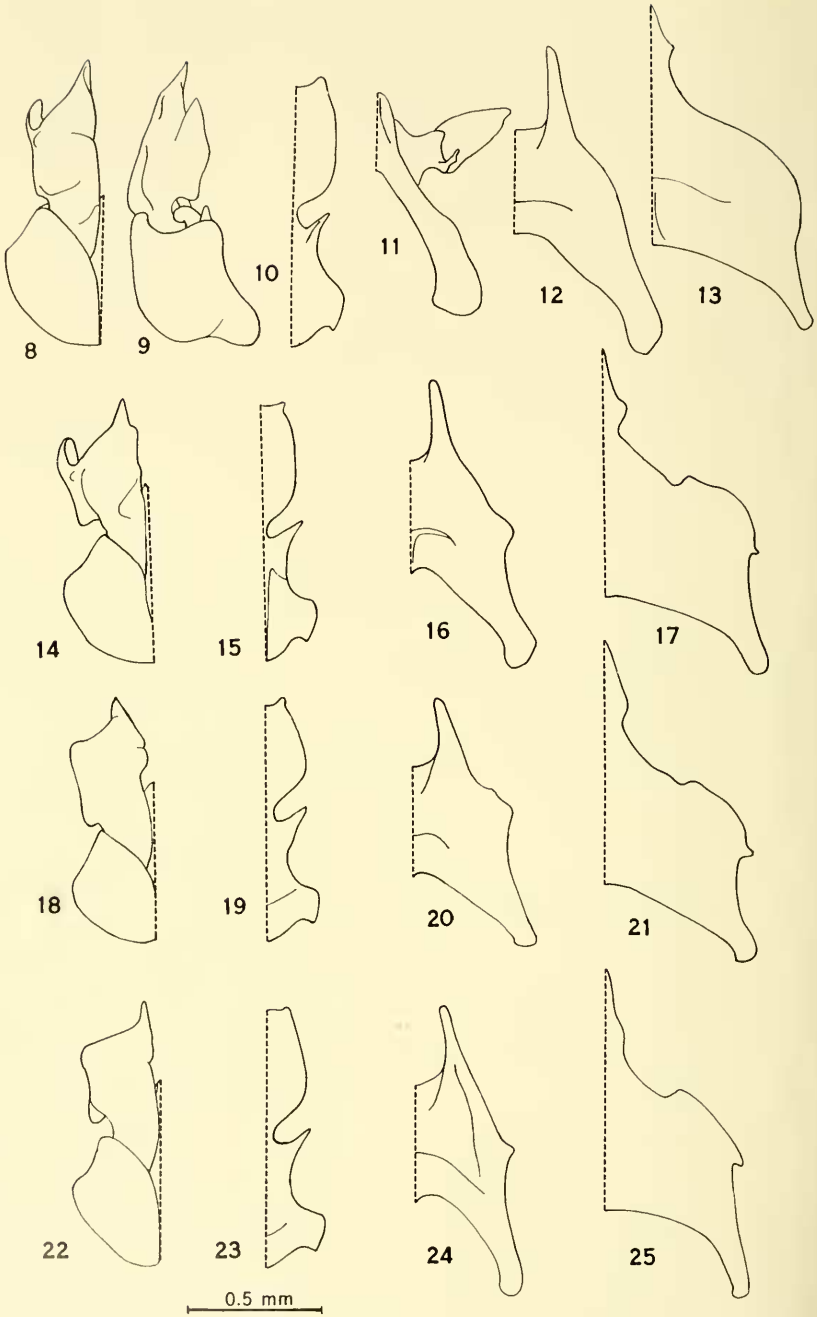
Introduction. This work on *Calliopsis andreniformis* Smith is meant to furnish a frame of reference for comparative studies in the biology and ecology of other species of *Calliopsis* and other burrowing bees. This is the most widespread and commonest member of the genus in the United States and Canada and is an apparently effective pollinator of many wild plants as well as alfalfa and various cultivated clovers.

Most of the observations were made on the campus of The University of Kansas at Lawrence, Kansas, with additional ones on the campuses of the public schools and of Stephen F. Austin State College at Nacogdoches, Texas; at Hancocks Bridge, New Jersey; and at Knoxville, Tennessee.

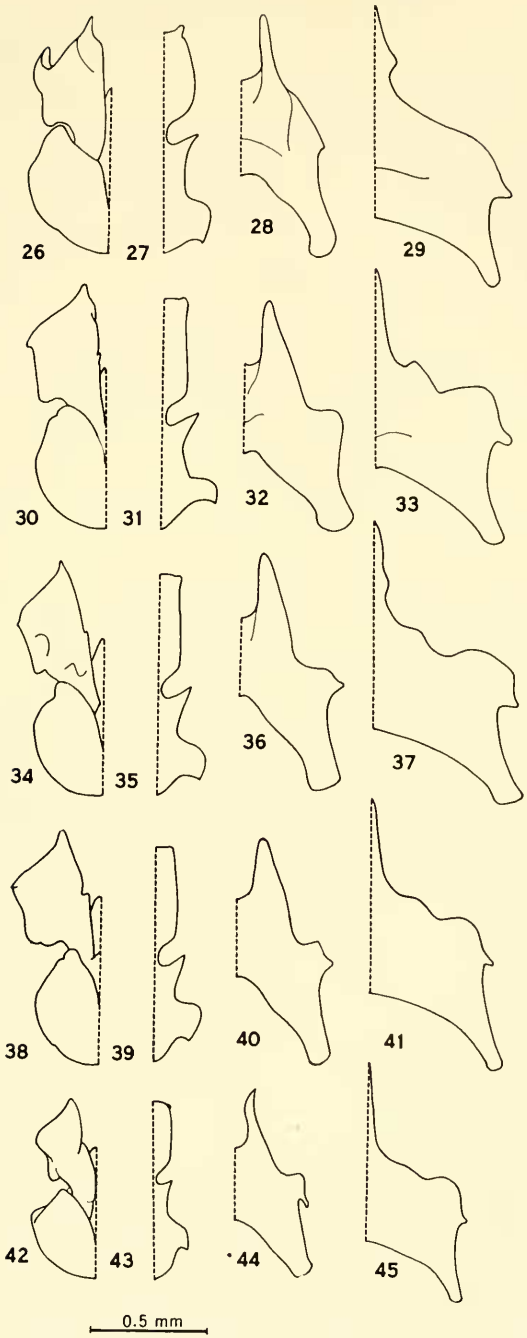
The Campus Bee has been proposed in the generic revision as the common name for this species because of its ubiquity on campuses of colleges and schools. Its closest relatives are *C. teucrii* and *C. hondurasica,* whose nest burrows are shown with those of *C. andreniformis* in Figs. 148-153.

Specimens documenting this study will be deposited in the Snow Entomological Museum of The University of Kansas, Lawrence, Kansas.

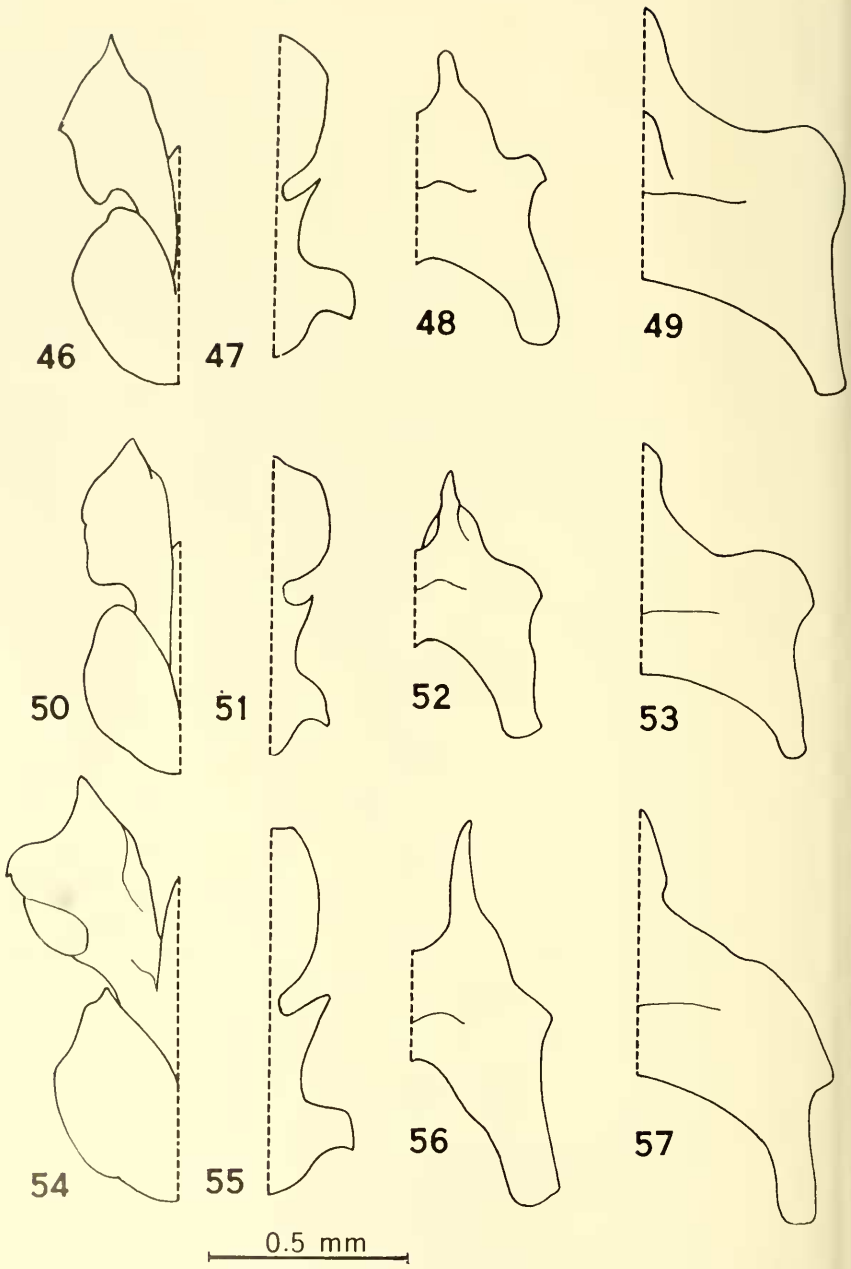
Techniques used in the study were in part obtained from Michener, Cross, Daly, Rettenmeyer, and Wille (1955). Weston dial thermometers were used



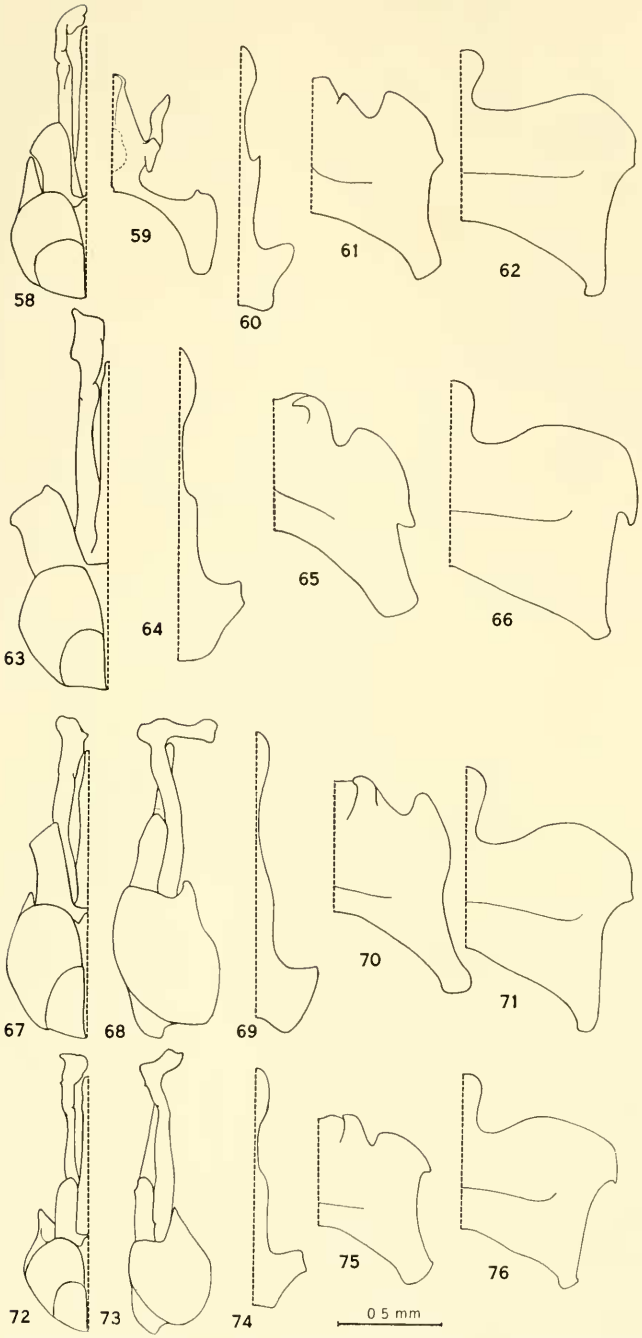
FIGS. 8-25. Male terminalia. Subgenus *Calliopsis*. Dorsal view of genital capsule (also lateral for *andreniformis*), ventral view of sterna 8, 6, and 5 (also 7 for *andreniformis*). 8-13. *C. andreniformis*. 14-17. *C. teucrii*. 18-21. *C. granti*. 22-25. *C. rhodophila*.



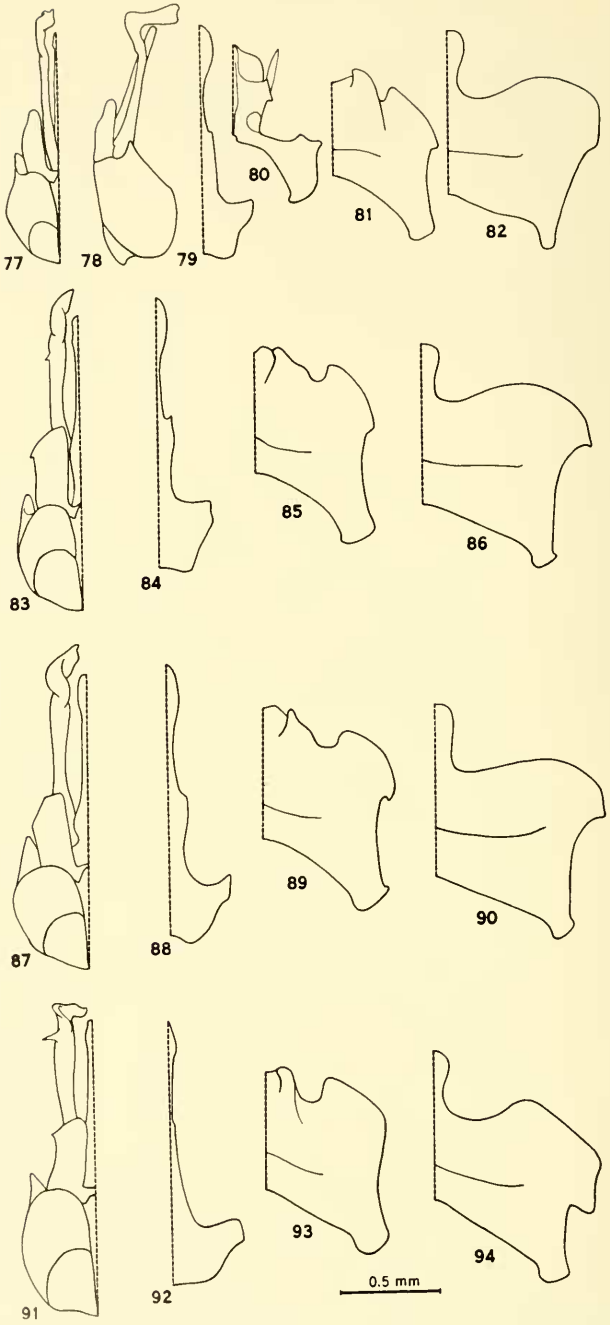
Figs. 26-45. Male terminalia. Subgenus *Calliopsis*. Dorsal view of genital capsule and ventral view of sterna 8, 6, and 5. 26-29. *C. mourei*. 30-33. *C. hondurasica*. 34-37. *C. sonora*. 38-41. *C. empelia*. 42-45. *C. squamifera*.



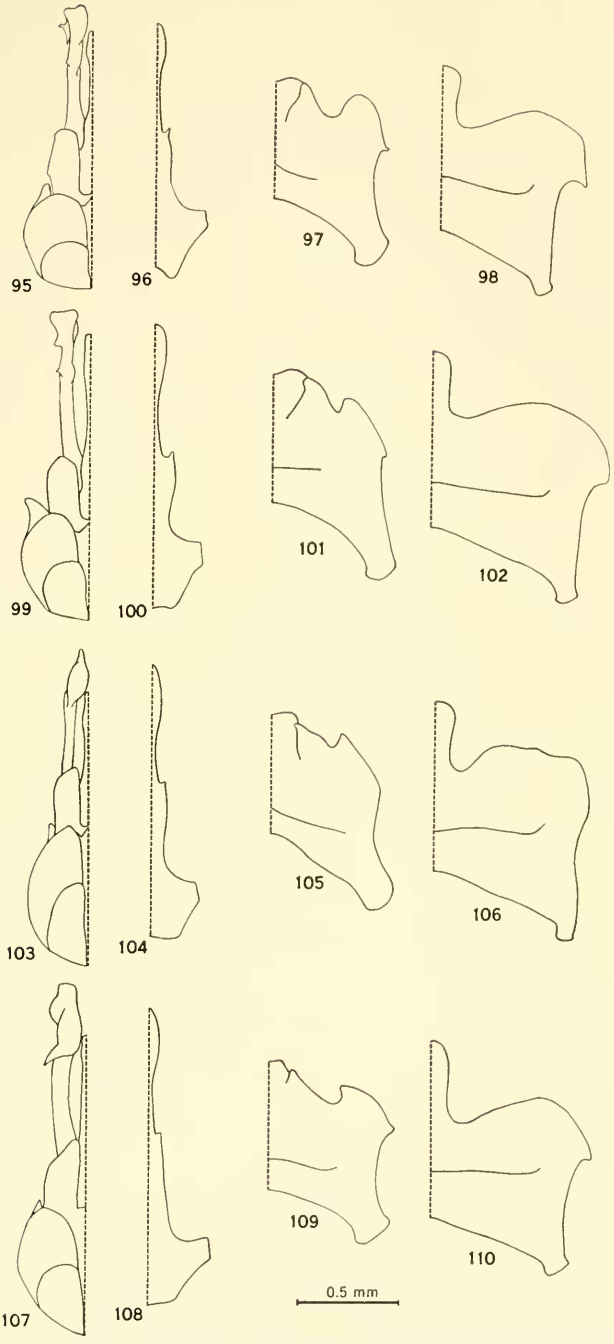
FIGS. 46-57. Male terminalia. Subgenus *Perissander*. Dorsal view of genital capsule and ventral view of sterna 8, 6, and 5. 46-49. *C. anomoptera*. 50-53. *C. rogeri*. 54-57. *C. gilva*.



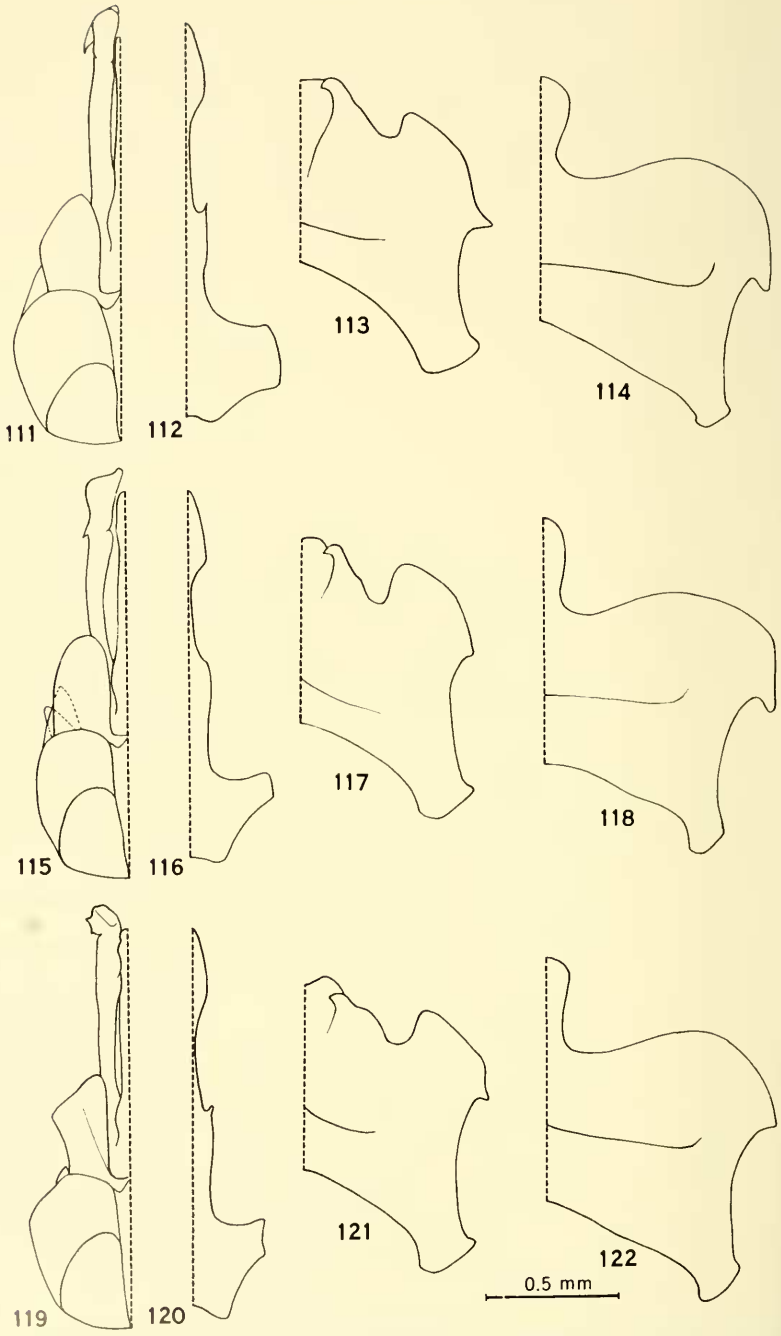
Figs. 58-76. Male terminalia. Subgenus *Calliopsima*. Ventral view of genital capsule (also lateral view for *pectidis* and *timberlakei*) and ventral view of sterna 8, 6, and 5 (also 7 *rozeni*). 58-62. *C. rozeni*. 63-66. *C. coloradensis*. 67-71. *C. pectidis*. 72-76. *C. timberlakei*.



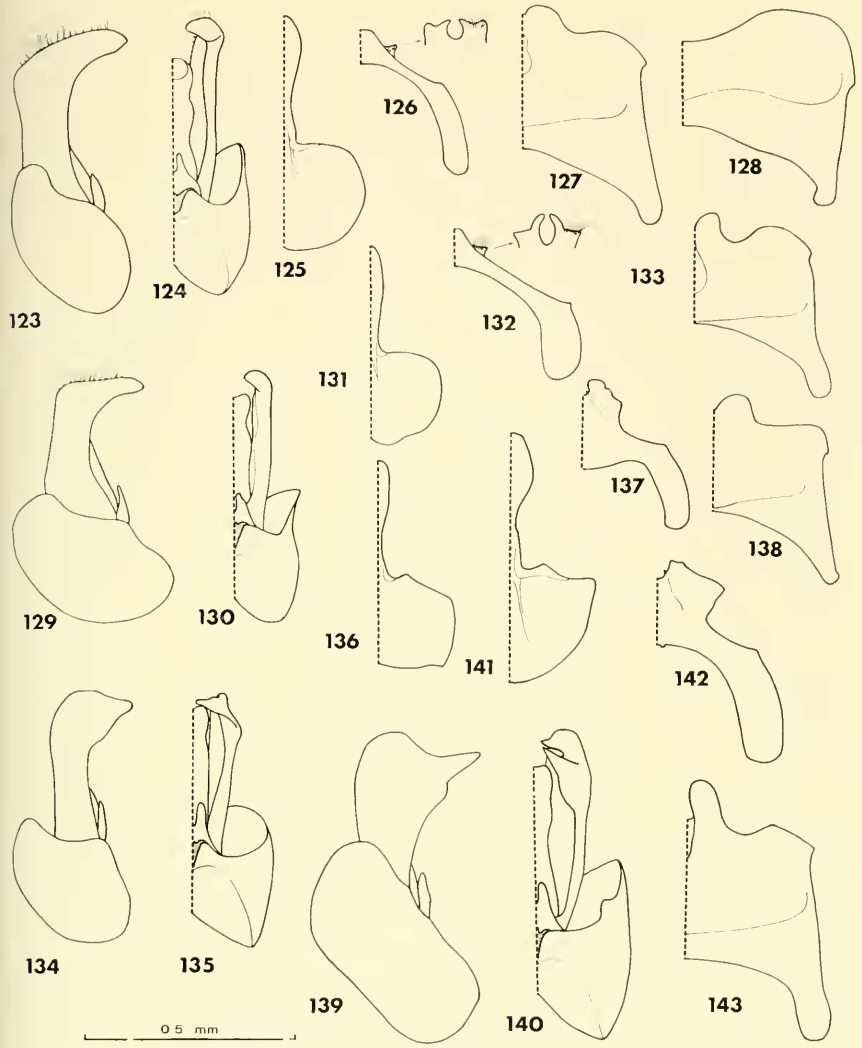
FIGS. 77-94. Male terminalia. Subgenus *Calliopsima*. Ventral view of genital capsule (also lateral view for *bernardinensis*) and ventral view of sterna 8, 6, and 5 (also 7 for *bernardinensis*). 77-82. *C. bernardinensis*. 83-86. *C. unca*. 87-90. *C. crypta*. 91-94. *C. azteca*.



Figs. 95-110. Male terminalia. Subgenus *Calliopsima*. Ventral view of genital capsule and ventral view of sterna 8, 6, and 5. 95-98. *C. chlorops*. 99-102. *C. coloratipes*. 103-106. *C. deserticola*. 107-110. *C. pugionis*.



FIGS. 111-122. Male terminalia. Subgenus *Calliopsima*. Ventral view of genital capsule and ventral view of sterna 8, 6, and 5. 111-114. *C. hurdi*. 115-118. *C. quadridentata*. 119-122. *C. kucalumea*.



Figs. 123-143. Male terminalia. Subgenus *Verbenapis*. Lateral and ventral views of genital capsule and ventral view of sterna 8, 7, and 6 (also 5 for *verbenae* only). 123-128. *V. verbenae*. 129-133. *C. nebraskensis*. 134-138. *C. hirsutifrons*. 139-143. *C. micheneri*.

for taking soil temperatures; fine copper screen cones were used for retaining bees as they came out of their burrows. Quick-drying acetate paints were used for marking individual bees, and roofing nails with yellow-painted heads bearing red numbers marked the locations of nest entrances. A string grid was fixed permanently in place for use in mapping the location of burrows. Excavations of nests were usually made by carving away the clayey soil with a sharp blade.

Because of its efficiency in pollinating legumes as well as a wide variety of other plants (see Table 8), *Calliopsis andreniformis* doubtless has an important ecological role in the maintenance of native flora. No quantitative assessment of this role has ever been made. Nonetheless, Crandell and Tate (1947) report that H. M. Tysdal observed (Unpublished, 1942) that the species was primarily responsible for very good seed set in alfalfa at Lincoln, Nebraska, over several seasons. They note, however, that *C. andreniformis* visits alfalfa flowers at a slower rate than *Megachile* and must be present in large numbers to effect a good seed set. Moreover, adults are present for a relatively short time, late June and July, and this limits their effectiveness. Their utilization in pollination would necessitate regulation of the flowering time of alfalfa or other plants involved to coincide with the period of adult activity. The same authors point out that this was not difficult at their nurseries in Lincoln, Nebraska, since the alfalfa blooms over a relatively long period.

My observations suggest that *andreniformis* would be a valuable pollinator of *Trifolium repens* and *Trifolium procumbens,* as well as alfalfa. Further discussion on the anthecology of the species appears under Flower Relationships.

The principal nesting habitat for *andreniformis* is bare, clayey soil, fully exposed to the sun, with leguminous plants of the clover group nearby. The farthest from a clover supply that any nesting site was located was about 59 m. In a tangled growth of virgin prairie on the campus of The University of Kansas, nests were made at the bases of the tall grasses and legumes in loamy soil. Even here preference was given to those small areas where the plants gave the thinnest cover, and the sun penetrated to the surface at least four hours daily. I have often found nests of the species in city ball parks or on school grounds, and these are the first places to look when in a new locality to see if the species occurs there in any numbers. Although the nesting sites usually have a slight slope, some very large aggregations have been found in flat fields, newly sown in clover and grass, e.g., football practice fields at The University of Kansas and at Stephen F. Austin State College, Nacogdoches, Texas.

The extremes of the flight period for the species are from early April to late September in the southern states, with peak activity in June and July; in the more northerly states it is from early June to early October, with peak activity in July and August.

A summary of the life history is as follows. The species over-winters as prepupae in closed, wax-lined cells in the ground. In spring the bees metamorphose and emerge as the active adults of the overwintering generation. Aggregations of males and females segregate by sex in digging their individual overnight burrows. In about a week mating is observed and females

begin nest construction by, 1) making a cell at the bottom of the overnight burrow; 2) beginning a new shaft near the mid-point of the overnight burrow; or, 3) abandoning the overnight burrow and digging a new one. Females typically construct two nests of three or four cells each, provisioning each cell with a spherical ball of leguminous pollen and laying one egg atop it. In about two weeks these eggs have given rise to the adults of the first summer generation. This generation in turn constructs nests and lays eggs, some of which give rise to the second generation and some of which enter diapause to overwinter as prepupae. Apparently most of the eggs laid by the second generation produce young which enter diapause, for the adult population drops drastically by the end of July. Individual females, however, lay about the same number of eggs, seven, as the females of the overwintering generation. A few adults provision nests as late as September. The last of the adults dies by early autumn.

Relatively few data are available on the continuity of nesting sites of *C. andreniformis*. Ainslie (1937) followed the progress of an "exceedingly active colony . . . in hard trodden ground in front of a grocery store at Sioux City, Iowa . . . three years under observation and study, then for unknown reasons colonies could not be found where they formerly were populous." Crandall and Tate (1947) had an aggregation under study for two consecutive years. Michener and Rettenmeyer (1956) mention a nesting site for *andreniformis* at Lawrence, Kansas, which apparently persisted from 1949-1953, and had not returned by 1959. My observations in Kansas and Texas indicate that *andreniformis* will stay at least three years in the same nesting site if flowers are available for pollen.

Study Sites. Sites used in the study are listed and briefly described below. Major nesting sites for *C. andreniformis* on The University of Kansas campus were designated Horseshoe, Sunnyside Field, Athletic Field, Gym Area (West Stake, East Stake, Gym Path), Prairie Acre, Curb, Corner, Malott Path, and Smoke Stack; major sites at Nacogdoches, Texas, on the campus of Stephen F. Austin State College and vicinity, were designated Stadium, Raguet School, and High School.

Horseshoe is the only locality found by me that sloped northward. It was about 91 m from Michener and Rettenmeyer's (1956) site, which also sloped northward. The soil at Horseshoe is clayey, probably a clay loam, and is covered by fine stones and pebbles to a depth of about five mm. The top 2.5 cm of soil are black with tan soil below. The area surrounding it is somewhat woodsy with considerable shade, but Horseshoe is in the sun from 10:30 a.m. till about 5 p.m. After rains, Horseshoe takes longer to dry out than any other locality where I have found *andreniformis*. Moreover, the dried soil splits and cracks more than at any other locality. Much *Trifolium repens* and *T. pratense* were there along with lesser amounts of *T. procumbens*. *C. andreni-*

formis was first taken one week later than at the localities on south-facing slopes. *Halictus, Agapostemon,* and *Lasioglossum* are also common on flowers here.

Sunnyside Field, Athletic Field, Gym Area, Malott Path, and *Smoke Stack* are sites with clayey soil, less dense than at Horseshoe, and in general resemble neglected lawns where the grass is relatively sparse and considerable *Trifolium repens* grows. *Halictus, Lasioglossum, Augochlora,* and *Apis* were common.

Prairie Acre is a remnant of the original prairie of the region, with abundant wild flower cover and native grasses. *Psoralea tenuiflora* was common along with *Asclepias tuberosa* and other milkweeds. The nesting sites were at the bases of grasses and flowers where the growth was slightly sparser than elsewhere. *Megachile, Lasioglossum,* and *Apis* were the commonest bees.

Curb and *Corner* were bare, with many small and large stones that interfere with burrowing. *Lasioglossum* was the only other bee there.

The Texan localities, *Stadium, Raguet School,* and *High School,* were very similar, and much like the description above for Sunnyside Field *et al.*

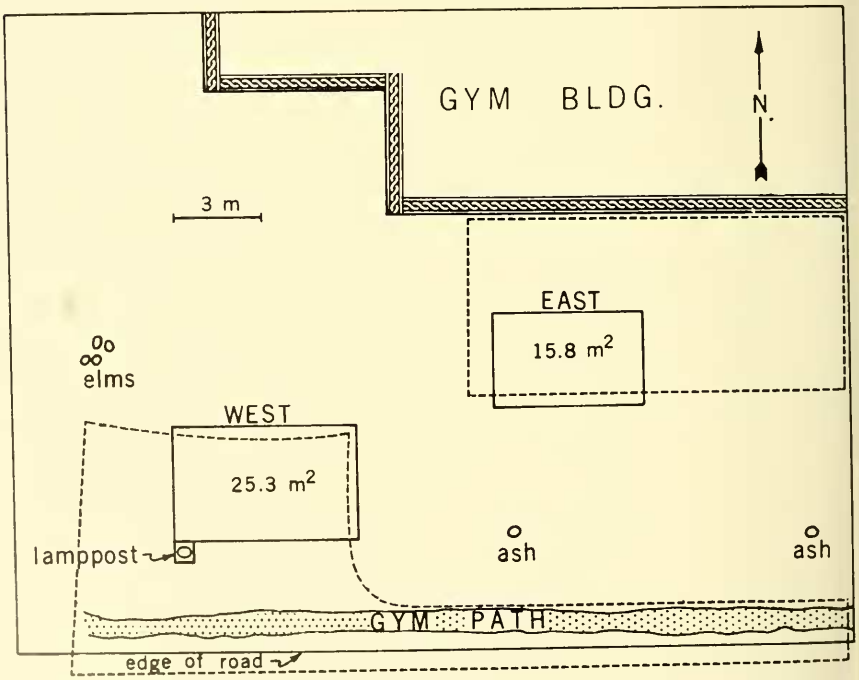


FIG. 144. Diagram of the East and West Stake plots at the Gym Area. The dashed lines enclose areas continuously exposed to sunlight from 10 a.m. to 3 p.m., whereas the remainder of the area was intermittently shaded by the leaves of the trees whose positions are shown on the diagram.

Panurginus polytrichous and *Lasioglossum* were the commonest bees at the *Calliopsis* nesting sites.

In order to study the seasonal development of nesting sites, two plots were chosen for intensive study during the summer of 1957 and 1958 in Kansas. Both were subdivisions of the Gym Area, called West Stake and East Stake (Figs. 144, 145, 146). A grid of squares 30 cm on a side was laid out on both areas with cord within about 3 days of the start of nesting activity on June 28, 1957. Arrangements were made to prevent cutting of grass by mowers in the area, and disturbance was otherwise minimized. The areas were close enough together that I could check activity on East Stake with binoculars while attending to other matters at West Stake. No emergence holes were present; the bees had just started this as a new area of aggregation and the full progression could be followed.

The soil at *andreniformis* nesting sites was of the loam, clay loam, or clay textural classes. At the Gym Area the soil became so hard upon drying that a scalpel was necessary to whittle it away in excavating burrows. The pH of the soil at the West and East Stakes was 7.43 to 8.79. Values for all other sites fell within these limits.

Distribution of Nests. Fig. 145 shows the distribution of nests in the West Stake plot, and a tabulation is made of them in Table 4. The density of nests varied with the barrenness of the soil. Bare soil, area 4, had about 6 times as many nests per unit of surface as the grassy areas 1 or 2, the vegetation of

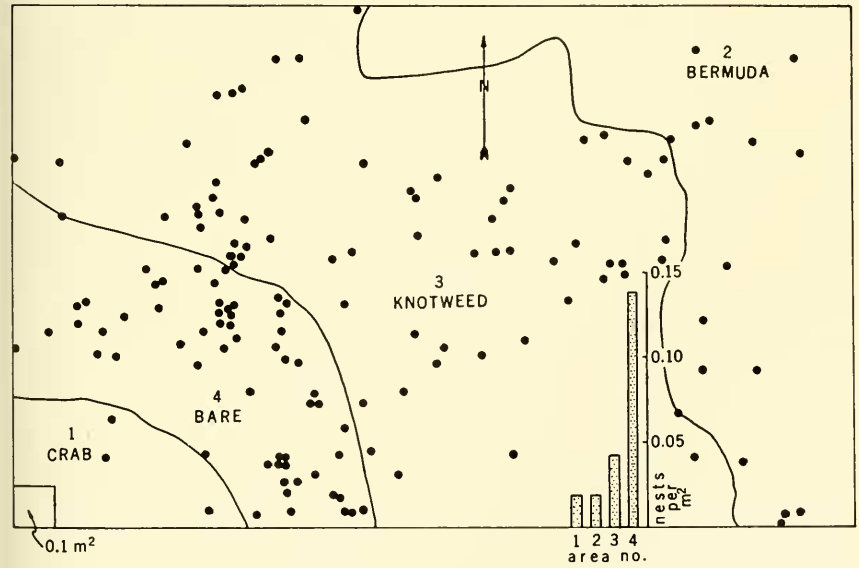


Fig. 145. Distribution of nests among different types of vegetational cover in the West Stake plot. The principal vegetation for zones 1 to 4 is indicated.

which covered a relatively large area of the soil. The density of nests in area 3 was about twice that in areas 1 or 2, and the vegetation of area 3 covered considerably less of the soil than that of areas 1 or 2. The density of nests was significantly different among the areas of the West Stake (Chi square equals 70.8, $P<0.001$).

TABLE 4. Distribution of Nests of *Calliopsis andreniformis* in the West Stake Plot (See Fig. 145)

AREA No.	Dominant plant	Area in m^2	Number of Nests	No. of Nests per m^2
1	*Digitaria decumbens*	1.36	3	2.21
2	*Cynodon dactylon*	6.65	15	2.26
3	*Polygonum buxiforme*	13.39	66	4.93
4	Bare	3.92	56	14.29
	TOTALS	25.32	140	

$X^2 = 70.8, P < 0.001.$

Calliopsis andreniformis will persist in a nesting site until the site becomes more than 80% covered with vegetation, provided that its pollen source remains available. The nesting sites at Lawrence held good populations of the species despite grass-sowing. When the normally preferred, hard-packed clayey soil sites acquired a cover of grass and clover, the bees accepted sites with surface layers of coarse sand 25 mm deep, and dug down through it to reach suitably firm soil. In observations at Lawrence from 1957-1959, and at Nacogdoches from 1960-1962, there was no evidence of appreciable fluctuation in numbers of nests or of social parasites where the physical state of the nesting site remained relatively unchanged. Where grass cover left less than about one-fifth bare area and had little or no admixture of *Trifolium repens, C. andreniformis* clearly migrated elsewhere. This occurred at the Texan nesting sites, Raguet School and High School, and at the Kansan sites, Horseshoe, Sunnyside Field, Malott Path, and the East Stake plot, all of which had previously held good populations of the species. Males remained at Prairie Acre despite the high density of herbage.

The most spectacular effect upon populations of *C. andreniformis* was brought about by man's activities. The following locations are close together on the south side of the campus at Lawrence. A football practice field at Lawrence having approximately one nest with five larvae per 3.7 m^2 was plowed to 15 cm depth, reconditioned, and sown with grass in May. 1958. In the summer of 1958 only ten nests were found in this field which carried at least 4500 bees prior to the reconditioning. Beside a curbing more than 200 nests were dug up in placing an electrical conduit, with a loss of about 1000 bees. When the West Stake plot was run over by a truck approximately 600

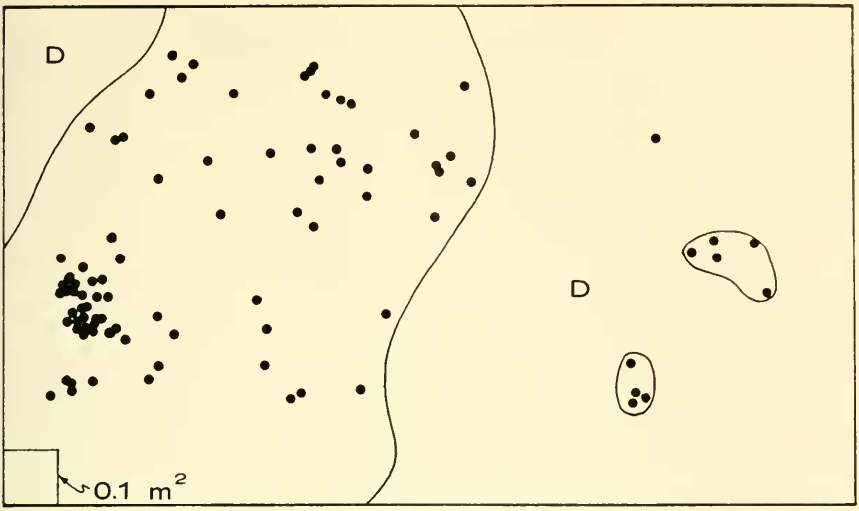


Fig. 146. Distribution of nests in the East Stake plot of the Gym Area. The letter D signifies a relatively dense growth of *Cynodon dactylon*.

bees were killed. Razing of buildings in the vicinity of the West Stake plot destroyed several thousand more. Thus between 7,000 and 10,000 *C. andreniformis* bees were destroyed in one season, the overwintering generation of 1957-1958, and the species was scarce in this locality in the summer of 1958.

Where *C. andreniformis* depends largely on *Trifolium repens,* it suffers when this clover is cut and its nectar and pollen become unavailable. This delays the time sequence of nest construction. On the other hand, cutting makes the clover season longer, and if the clover is not all cut at one time, the net effect is to extend the total length of the bee's active season.

A study of the changing pattern of sunlight and shade revealed that every nest burrow was located so as to receive continuous sunlight for 5 hours between 8:30 a.m. and 4:30 p.m. Especially striking was the absence of nests in bare ground along the southern strip of the East Stake. This seemed to be ideal nesting territory but *andreniformis* did not nest there, presumably because two ash trees cast a strip of shade there as the day progressed. I watched females come down to the shady area and investigate it for digging. Each often returned several times but eventually went a few inches north into the East Stake area and burrowed there (Fig. 146).

The bees are active up to 54°C soil surface temperature. At this temperature, however, they plunge quickly into their burrows and seldom loiter about on the hot surface. They fly, or attempt to fly, in winds up to 32 km per hour, but gusty winds of 48 km per hour discourage them and they spend much time in their burrows. Air temperatures between 27°C to 40°C characterized their most active flying periods with diminishing activity as temperatures fell

to 21°C at which most flying ceased. In the soil they are sluggish at such temperatures. The area receiving continuous sunlight from 10 a.m. to 3 p.m. is shown in Fig. 144. Many suitable nesting sites were available for *andreniformis,* and numerous small aggregations of nests were scattered around the campus, mostly on the southward slopes. Other nesting sites were found within the city of Lawrence, but human activities usually ruined them for study.

Although nests of *andreniformis* characteristically are aggregated, there are always some that are rather isolated from others. Although it does not seem to hide its burrow entrances deliberately, it does succeed in doing so very effectively on occasions. About 10% sink their shafts against and under a twig or a leaf that is fairly well anchored in the ground. If large enough, such an object covers the tumulus. I have seen nests under prostrate dandelion leaves, aluminum chewing gum wrappers washed into the soil, and stones about 2 cm in diameter. Rozen (1958) has described a similar tendency in *Nomadopsis.*

At Horseshoe I initially netted *andreniformis* females but could not locate their tumuli. Since the resting burrows of males were readily located, the female burrows were expected nearby. I found them at the bottom of soil cracks as large as 150 mm deep by 13 mm wide. This location would have serious disadvantages when the next rain came, and likely would wipe out many of them as the cracks closed.

Sequence of Nesting in Relation to Physical Factors. The sequence of nesting activity at the Gym Area in the East and West Stake plots, including the air and soil temperatures and rainfall is given in Fig. 147. The first nest burrows appeared after a rainfall of 1.6 cm which followed a dry period of 12 days during which less than 2.1 cm of rain fell. It seems likely that this sudden, drenching rain, which fell mostly between 8 and 11 a.m., triggered the nest-building activity at the Gym Area.

The first burrows appeared on June 29th and all activity ceased after August 13th, a span of 47 days. The bees which arrived to nest were doubtless the first generation (offspring of the overwintering generation). Emergence of the first summer generation is between four and six weeks after emergence of the overwintering generation. Most likely these bees emerged from a revegetated area which was bare the year before and migrated to the bare Gym Area.

The rainfall of their first four days in the area made burrowing easy, and the total number of active nests rose rapidly to a peak on the sixth day. As the soil dried and soil temperatures rose, burrowing activity dropped to a minimum until the next soaking rain on the 13th and 14th days, June 9th and 10th. Again the total number of active nests rose to a maximum on the sixth day following the rain. The second peak of activity is much broader than the

first and represents the emergence of the second spring generation plus further burrowing of the first spring generation. Most burrowing activity had died down by the 27th day, July 24.

I decided to wet the plots using a garden hose; enough water was sprayed to moisten the soil to a depth of six to seven cm, that is, to the level of the first to third cells below the ground. I believe the third, weak peak of burrowing activity is attributable to this watering, but I had no control test for it. Fifty-five dormant nests were reactivated.

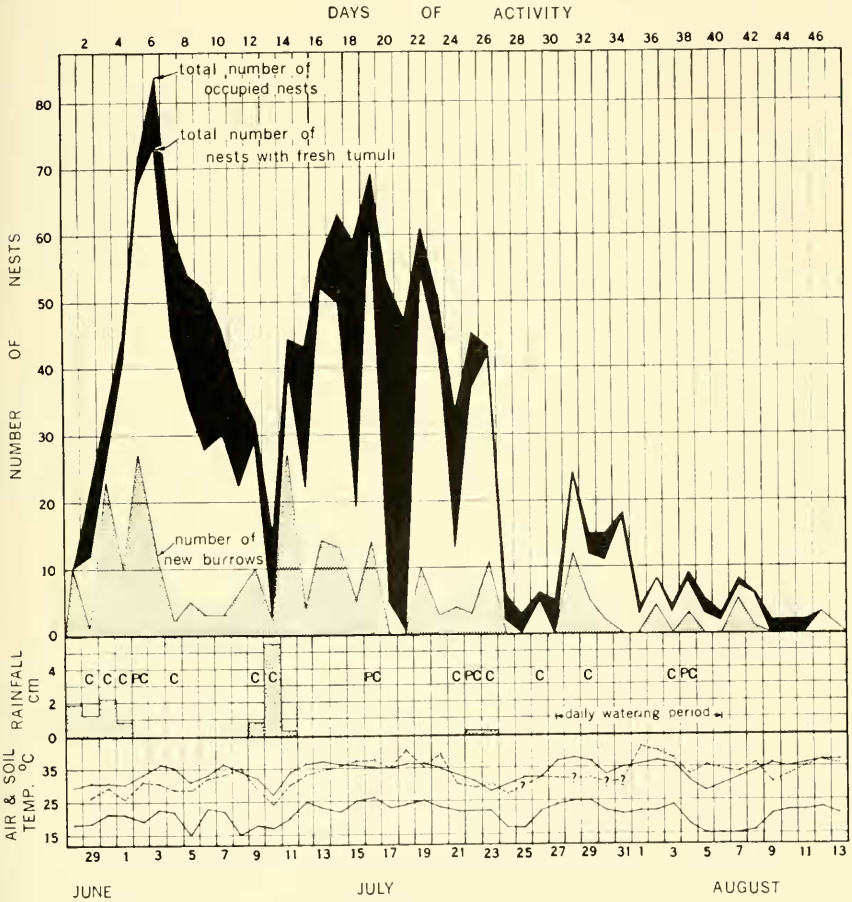


Fig. 147. Graph of nesting activity at the Gym Area. The solid black area gives a measure of the nests which are not abandoned, but are inactive for a particular day. The white area includes nests previously begun and currently active, while the stippled area shows the number of active nests on a particular day which are new burrows. In the rainfall diagram, C means cloudy, PC means partly cloudy, and days without a symbol were clear. The daily maximum and minimum air temperatures are connected by solid lines; the dashed line connects values for maximum soil temperatures at a depth of 12 cm. The question marks signify that no value was recorded for that date.

SPRING EMERGENCE. The nest burrow fills up completely with soil during the winter months of rain and snow, freezing and thawing. The adult emerges by crawling through the soil plug in the neck of the cell; it does not break through the waxed wall. Apparently it displaces dirt behind it into the cell as it digs its way out. Emergence holes are close to the original burrow entrance. Males and females appear almost simultaneously, but more males appear to emerge than females.

The factors which influence emergence of the overwintering brood are soil temperature, in turn influenced by slope, exposure, and rainfall. As mentioned previously, bees nesting on a south slope are out a week earlier than those on a north slope.

The emergence of the overwintering brood was best correlated with the flowering of *Trifolium repens* (White Dutch Clover, the common lawn clover) at Lawrence, Kansas; Nacogdoches, Texas; and Knoxville, Tennessee. The species usually emerged about a week after the first flowering of *T. repens*. At Lawrence, *T. procumbens, Melilotus officinalis,* and *Verbena bracteata* flowered within a week of first emergence of *C. andreniformis* in 1957-1959. This close synchrony did not hold true for *T. procumbens* and *M. officinalis* in Texas, 1960-1962, or in Tennessee, 1963-1964, and the last species was not found in the Texas or Tennessee study areas.

PRENESTING ACTIVITY AND RESTING BURROWS. The prenesting activity lasted 7-12 days at different sites. Females and males flew about the area from which they emerged, resting on the ground or on sticks, twigs, and light-colored objects. Females were especially attracted to the painted yellow heads of the roofing nails used to mark burrows.

Although some 40 marked female bees which emerged from an established aggregation in the Gym Area dug burrows there, some bees possibly migrated out of their original area either by intent or because they did not know the landmarks well enough to return. I lost 10 out of 20 marked males and females at Smoke Stack in 1958 within 10 days after their emergence (death or predation could, of course, have caused the loss).

At night the females rest in vertical or slightly slanting, closed burrows which they dig about 50 mm deep. The males do not rest in burrows with the females but make their own, which are usually about 25 mm deep. When the nesting site is established, males rarely have overnight burrows among those of the females, or even on the fringe of the site. They usually are as much as 6 m from the nearest female's nest.

At Prairie Acre 12 tumuli of males were crowded into an area of 0.046 m^2, some within 25 mm of each other, with a 10 mm depth. Many more tumuli were scattered around the edges of a patch of *Psoralea tenuiflora*. The burrows were initiated between tangled roots. The ground stayed damp because

of the density of the vegetation. I trampled down some of the grass so that sun would shine to the ground, and many more tumuli appeared in this spot than in the less accessible and damper areas.

Two males at *Horseshoe* were timed from the start of digging of their burrows until the last movement was seen in the tumulus covering the burrow. A large male began at 3.25 p.m. and finished 34.5 minutes later. The resultant conical tumulus was 15 mm wide and 9 mm high at the center. A smaller male began at 4:28 p.m., same date, and finished 36.5 minutes later at a depth of 25 mm. Both males and females return to their same burrows night after night. The female usually deepens her burrow into a nest but may dig a new burrow or make another tunnel down from the original entrance.

Both sexes dig with their mandibles and their front feet, passing the dirt along under them and giving it an expeditious kick out of the burrow. As dirt accumulates and begins to drop into the burrow, the bees apparently pass the dirt upward as before and then press it upward with the tip of the abdomen.

Night burrows of male and female can be distinguished because the tumulus of the female is much the larger of the two. The average dimensions of 104 tumuli cast up by females by 7 p.m. of the first night's digging of a burrow were 23.3 mm wide by 6.1 mm high. The comparable figures for 9 males were 11.4 mm wide by 4.5 mm high. The largest tumulus of a male was 13 x 18 x 4 mm high at the center. The smallest tumulus of an overnight burrow of a female was 20 x 12 x 4 mm high, with nearly all others being larger than 20 mm diameter by 7 mm high at the center. The periphery of the tumulus of *andreniformis* is not always round; a slightly compressed circular outline or very broad oval frequently results from the way the soil is pushed out of the burrow.

Mating and Male Patroling. Mating takes place on clovers (rarely) or other flowers or at the nesting site. Stevens (1950) took mating pairs in North Dakota on *Lactuca pulchella* (Blue Lettuce) in early July. Mating attempts at clovers usually are met with evasive action or resistance by the female. At the nesting site a male advances from behind, mounts the female, usually biting at her wings. Copulation lasts 2 minutes or less. Sometimes the two fly away *in copulo*. I have only a single record of a female which was mated more than once during the brief time I kept her in sight, and she did not resist a second mating. Often the first male on the female is pulled off as a succession of males try to mate with her. Females with huge pollen loads mate in the nest area.

The males patrol fairly well prescribed routes which they seem to consider their own property. They choose a favorite spot in this route—a twig, stone, or leaf—and set forth in a definite flight pattern, then return and alight repeatedly at the same place. If another male intrudes upon this flyway, an

aerial "dog-fight" occurs. The two rise vertically, tumbling over each other in aerial acrobatics. If one catches hold of the other they fall to the ground, kicking up dust and biting each other. The intruder soon leaves, as I know from four marked males that became involved in such fights. This seems to be a clear instance of territorial behavior. The flyway is from 2 to 5 m long, and is not necessarily straight. Two males may have adjacent flyways with one loop of one overlapping that of the other; if they chance to meet a fight is sure to ensue. Males captured and marked with paint return to their flyways as if nothing had occurred. Two records of different males give some idea of the amount of time spent in a flyway versus that spent flying over nearby clover. One male spent three minutes in the flyway, one and a half minutes over clover, then ten minutes back in the flyway. During the ten minutes in the flyway it rested on the ground for periods of 11, 8, 3, 6, and 6 seconds respectively. A second male alternated between flyway and clover as follows: 5, 2, 6, 5, and 3 minutes respectively.

I have never seen a male try to copulate with any insect or object other than a female *Calliopsis*. An apparently non-receptive female is sometimes pursued from flower to flower by a number of males.

NEST STRUCTURE AND CONSTRUCTION. In beginning her burrow, *andreniformis* shows a characteristic pattern which I have not seen in other bees. She bites the soil into a sloping arc to make her entranceway, then digs the shaft more or less perpendicular to the ground level. The female may begin several entrances, some clockwise and some counterclockwise, before proceeding with the sinking of the shaft. Females with full pollen loads dig burrows with front legs and mandibles. Wille and Michener (1951) give a female's progress as 44 mm in 30 minutes digging. The rate of progress depends upon soil moisture. They do not carry water but wait until the soil is moist enough to work. Hence, immediately after a rain, numerous tumuli appear. Many are made by bees that have not dug previously, but some are made by females that have provisioned three or four cells (evidence from four marked females). They may start a new nest rather than sink the first one deeper. This seems a waste of energy, for the average depth to the top of the first cell is 54 mm, whereas later (lower) cells are made with an average vertical distance between them of only 7 mm, usually at different compass bearings from the main shaft.

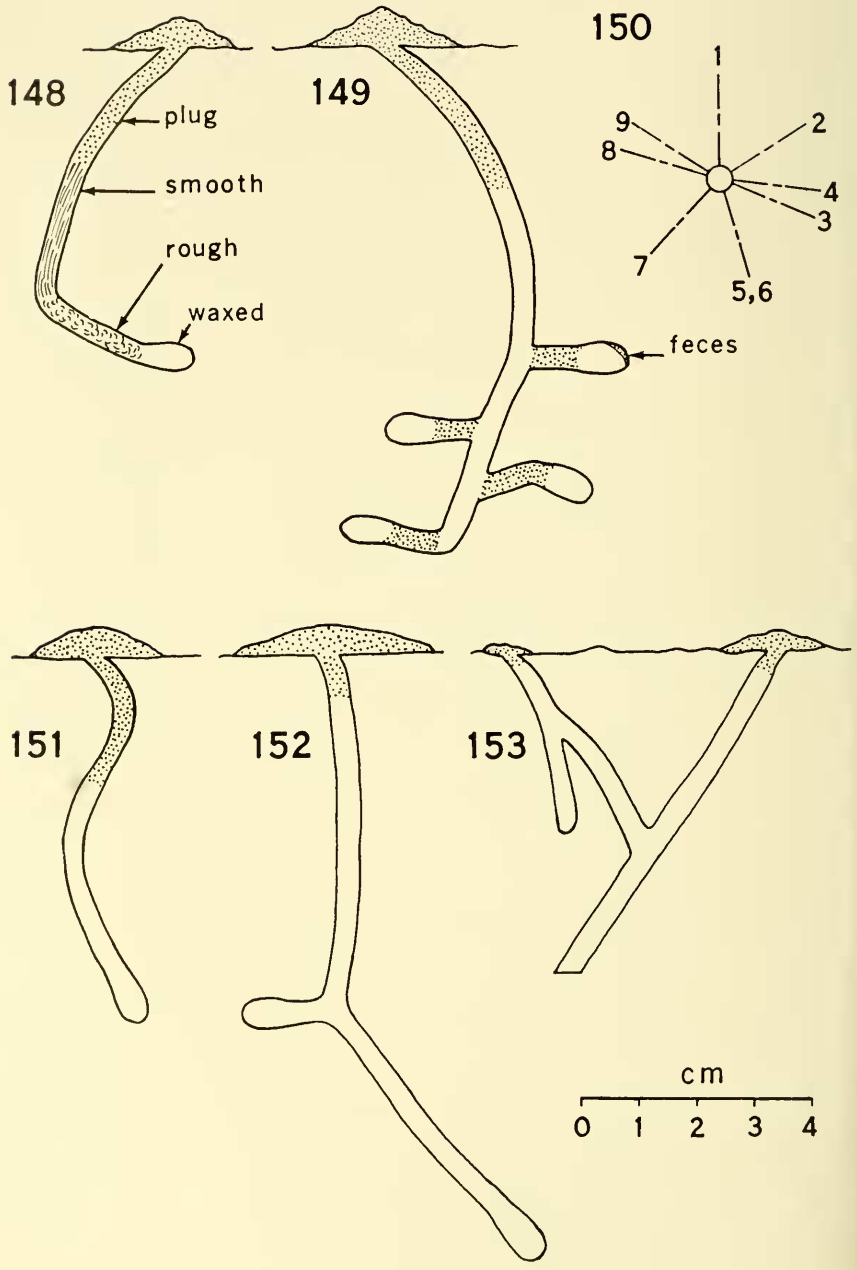
The tumulus thrown up seems always somewhat moist, and it may be that it is at this time that the female imparts an odor to the tumulus, possibly by adding secretions to the soil to soften it. The tumulus is always a closed mound, the entrance of the burrow being filled by the loose soil. Wind or rain will eventually obliterate the tumulus, but the upper 25 mm or more of the burrow remains filled with loose dirt. The female may chew out some of the upper wall of the burrow to keep an adequate dirt fill in the shaft.

Pickles (1940) reported that the tumulus of *Andrena armata* is more alkaline than the ordinary soil from which it is dug. His published data, however, are not statistically significant for the soil of the mounds, although the central core is decidedly more alkaline than the ordinary soil or the soil of the rest of the mound. Twenty-six paired samples of soil dug from burrow walls and the tumuli from the same nests from several localities were tested for differences in pH. A glass electrode pH meter and soil:water ratios from 1.10 to 1:17.5 were used for the tests. The mean and standard error of the pH of the soil of the burrow walls was 8.169 ± 0.0590 and that of the tumuli was 8.198 ± 0.0666; the difference is not statistically significant. The range in pH of the samples was between 7.4 and 8.6.

Diagrams of the nests of *C. andreniformis, C. hondurasica,* and *C. teucrii* are shown in Figs. 148-153, and Table 5 gives dimensions for nests of *C. andreniformis*. The diameter of the main shaft of *andreniformis* is sometimes slightly constricted at ground level by 0.5 to 1.0 mm, and this applies to the only nest of *teucrii* found. Professor Alvaro Wille of the University of

Table 5. Dimensions of Burrows of *Calliopsis andreniformis*

(All dimensions are in mm)	*N*	*Mean*	*Standard Error*
Diameter of burrow, 25 mm below ground level	18	3.688	0.1291
Same, male burrow, 10 mm below ground level	4	2	NA
Length of plug at entrance	14	32.0	3.04
Depth to top of first cell	70	55.16	1.416
Depth to top of second cell	49	62.90	1.426
Depth to top of third cell	31	72.68	2.087
Depth to top of fourth cell	22	80.32	2.365
Depth to top of fifth cell	16	83.81	2.261
Depth to top of sixth cell	9	86.80	2.351
Depth to top of seventh cell	9	83.22	0.707
Depth to top of eighth cell	9	90.89	1.871
Depth to top of ninth cell	9	97.66	2.483
Depth to top of tenth cell	3	106.00	1.155
Minimum depth to top of first cell	1	34	NA
Maximum depth to bottom of last cell	1	162	NA
Weighted mean number of cells per nest	70	3.375	NA
Depth of female overnight burrow	15	51.20	2.590
Depth of male overnight burrow	26	26.00	1.277
Length of lateral burrow	16	8.00	0.713
Diameter of cell	17	3.871	0.0757
Length of cell	19	7.842	0.2356
Diameter of first night's tumulus, female	20	22.90	0.894
Diameter of first night's tumulus, male	9	11.56	1.291
Maximum height of first night's tumulus, female	20	6.75	0.673
Maximum height of first night's tumulus, male	9	4.56	1.232


148
plug
smooth
rough
waxed
149
feces
150
1
2
3
4
5,6
7
8
9
151
152
153
cm
0 1 2 3 4

Costa Rica drew the nest diagrams of *hondurasica* based on excavations he made in a little used road at Playa del Coco, Guanacaste Province, Costa Rica. The only dimensions he recorded were the depths of cells. The architecture of all three species is closely similar so far as is known. No data are available on the cells of the nests of *teucrii*, but the diameter of the burrow is 4 mm, which falls within the range for that of *andreniformis*.

After the entrance has been made the nest may be continued vertically downward or may slope; in the latter case it may be irregularly helical. If helical, the burrow usually follows the direction of the arc set at the entrance hole. Only one cell is placed at the end of each relatively short, lateral burrow. If the main burrow is a helix, the cells may be built off from it regularly clockwise or counterclockwise as the helix goes deeper, but some cells show regressions (Fig. 150, cell 4), and others are built one directly below another.

Only two nests of *andreniformis* with a double entrance were discovered in the course of the study. Several nests had a single opening with a slanting, blind burrow of about 50 mm depth to one side slightly below the entrance. Probably these were cases where females dug new burrows rather than deepening their night burrows of the prenesting period. The only nest positively identified as that of *C. teucrii* had both a double entrance and a blind burrow (Fig. 153).

One nest was provisioned by two different females at the same time. Unfortunately this was one of the casualties when a truck ran over the West Stake site and I do not know the architecture of the nest. Two instances were found, in August 1957, of females taking over abandoned, provisioned nests. The second females added 3 and 4 cells respectively to nests of 5 cells and 3 cells. This was determined by dusting bees and tumuli with metallic red powder when they first took over the nests, and then observing which cells of the excavated nests showed the metallic powder.

The cells for the developing young are short, oval, and the short lateral burrows to which they are attached often slant *up* from the main shaft. The cell slants slightly downward toward its apex. The neck is closed with soil, packed tightly and filling the lateral burrow (Fig. 149). The interior of the cell is beautifully smoothed and coated with a wax-like substance which is insoluble in cold carbon tetrachloride, cold 95% ethyl alcohol, and cold water, but dissolves instantly in ethyl ether. The thin, pliable coating of the spherical pollen ball in the cell is demonstrated by placing the ball in glacial

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Figs. 148-153. Diagrams of nests of three species of *Calliopsis*. Fig. 148. *C. andreniformis*, showing regions in a burrow. Fig. 149. *C. andreniformis*, a typical nest for the species. Fig. 150. *C. andreniformis*, top view showing disposition of cells about the central burrow; cell 1 is uppermost and this nest is a "clockwise" nest except for cell 4. Figs. 151, 152. *C. hondurasica*, as interpreted from field sketches from Prof. Alvaro Wille. Fig. 153. *C. teucrii*, Coaldale, Colorado.

acetic acid and slicing it with a sharp blade. The internal pollen mass retracts from the coating and is easily seen.

Cells are made and provisioned from the upper level downward. The time required to complete a nest varies with the kind of weather, and, on The University of Kansas campus, with the frequency and thoroughness of mowing the grass and clover mixed with it. Infrequent mowing allowed the bees to have clover supplies for relatively long periods of time between drastic drops in their major pollen source.

A female of *andreniformis* customarily makes two nests. The average number of cells per nest is about 3.4. This figure is derived from excavations of burrows where activity had ceased, and may be biased by accidental death of the maker (see Table 5). It is my impression that nests made later in the season when the ground is hard and dry are more frequently deeper with more cells per nest, but I lack adequate data to substantiate this impression. The largest number of cells found in a single nest was ten, in a nest dug in Malott Path, August 1957.

Other than the chasing of *Holcopasites* out of the nesting area by the male *andreniformis,* I have seen nothing which would be construed as a protective tactic. The female did not even try to re-establish the tumulus over her burrow when I pushed it aside, but the tumulus did not seem to discourage social parasites anyway, with the possible exception of *Parabombylius,* which only flips eggs into burrows without tumuli.

IMMATURE STAGES. Table 6 gives sizes and weights of eggs and pollen balls. The eggs are slightly arcuate upward when in position on the pollen ball, have rounded ends and their middle portions may contact the pollen ball (Fig. 154) or may be raised above it. At a temperature of 30°C six eggs

TABLE 6. Physical Data on Adults, Eggs, and Provisioning of Nests of *C. andreniformis*

	N	*Mean*	*Standard Error*
Weight of female, mg	23	12.35	0.367
Weight of male, mg	5	6.440	0.1311
Length of egg, mm	6	1.295	0.1213
Width of egg, mm	6	0.3666	0.02646
Length of pollen-collecting trips, minutes	13	70.5	9.97
Time spent in nest between pollen-collecting trips, minutes	15	7.33	2.964
Pollen load (both legs), mg	7	1.529	0.1460
Pollen ball, mg	7	10.86	0.407
Pollen ball, diameter, mm	11	2.475	0.1567
Calculated number of trips for one pollen ball	7	7.10	0.71

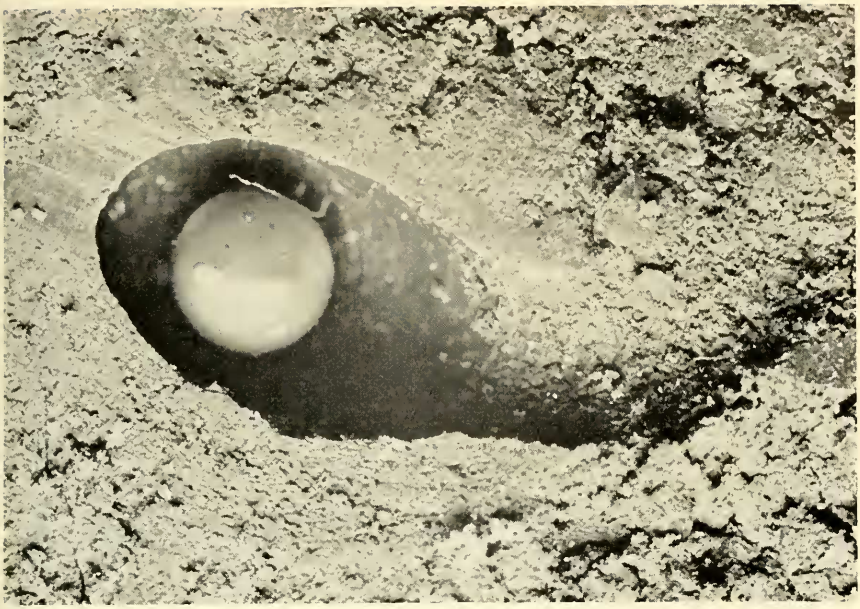

Fig. 154. Top view of the wax-lined cell made by *Calliopsis andreniformis* showing the pollen ball and egg in place. Note the mandibular markings in the wall of the lateral near its junction with the neck of the cell. The broader end of the egg is the anterior end and faces the opening of the cell.

hatched in between 24 and 48 hours. The exact time of hatching is difficult to determine because the chorionic membrance is not visibly shed, but rather seems to be absorbed.

The egg is oriented with the broader, head end toward the entrance, or plug, of the cell (Fig. 154). The posterior end is somewhat tapered. When the egg becomes a first instar larva, the larva seems to spread a secretion on the pollen ball surface, then uses its mandibles to break into the pollen ball. Perhaps it is a combination of a secretion and the action of the mandibles that opens up the enveloping coat of the ball and allows the larva to begin feeding. As the larva continues to feed, it eats downward on the pollen ball so that it eventually rests on its back, rear toward the entrance of the cell, a vestige of the pollen ball on its venter, and head toward the apex of the cell. Wille and Michener (1951:56,59) made similar observations.

After the larva has fully fed it reorients with its head toward the cell entrance and rests for 2-4 days. Defecation then begins, with the excrement being plastered on the distal, upper end of the cell wall (Fig. 149) by the lateral and circular movements of the posterior end of the larva. Several fully fed larvae were placed in gelatin capsules which approximated the curvatures of their cells. They performed the above process visibly within the capsules.

Larvae do not have to have a wall against which to void excrement. They will do so lying on their backs in the small plaster rearing cells described under laboratory rearing methods. In the latter case the excrement is voided as a stringlike mass which coils itself under the larva. Under such conditions the excrement often is like a string of toad eggs, each segment somewhat flattened and about 0.33 mm long. This long golden length is followed by pasty, gray matter which is smeared uniformly over the other excrement on the cell wall.

Molting larvae presumably eat their shed skins as none are found in the cell. It takes the developing larva 6-8 days to consume the pollen ball at a temperature of 27°C. After defecation the larva can either become quiescent for 3-5 days and then pupate, or it may go into diapause. Fig. 155 shows a lateral view of two overwintering prepupae, and Michener (1953a) described and figured the prepupal head, mandible, spiracle, and full lateral view. The pupal stage lasts about 10 days in the summer. After the pupal skin is shed, the adult remains quiescent, and in about 36-48 hours a gray liquid suspension is voided. The adult usually remains inactive for a day or so under laboratory conditions; after that it becomes active.

An attempt was made to differentiate male and female prepupae on morphological or morphometric bases. No significant external morphological difference was found between the sexes. There was so much overlap of prepupal weight, width of head capsule, width of body, length of body, and intertubercular distance that these measurements were impractical to use for separation of sexes.

Laboratory Rearing. Immature specimens of *C. andreniformis* from egg to prepupal stage were taken from cells and placed in various containers at different relative humidities and temperatures in order to rear them to adulthood. No eggs or young larvae were reared through to adults. The earliest stage which was reared to an adult was one in which the pollen ball was about two-thirds consumed.

The most convenient rearing container for a large number of specimens was a cigar box coated with paraffin and with its top replaced by a piece of glass for observation of the specimens. The cigar box can be made airtight with putty. It may be important to isolate specimens from each other if mold spore contamination is widespread. In order to handle individuals easily, small rectangular blocks 18 x 25 x 9 mm deep were made of plaster of Paris and a depression 8 x 12 x 5 mm deep of the approximate shape of the lower half of a bee cell was excavated in it by means of a hand-held grinding tool. The depression of the block was coated with paraffin. The upper surfaces surrounding the depression would take pencilled identification symbols. With this system individuals could be easily shifted from container to microscope stage with the least disturbance.

Obtaining specimens for laboratory work was an exasperating undertaking. Excavation was not difficult, but opening the cell containing the developing bees without getting grains of dirt on the pollen ball, egg, early developing larva, or, worst of all, in the moisture condensate often found in

Fig. 155. Vertical section through two cells of a nest of *Calliopsis andreniformis* showing the overwintering prepupae in place. Note that their heads are towards the openings of the cells. The larval feces are seen near their posterior ends on the upper distal surfaces of the cells.

the cell around the bottom of the pollen ball, required painstaking precautions and luck! If a small piece of dirt lodged on the egg it could often be removed with very fine jewelers forceps. If it fell on the first stage larva a watery "blister" appeared and the larva died; if on the pollen ball, it was usually quickly dispersed on the wet surface and mold invariably grew there, killing the immature form; and, if in the cell condensate, mold usually resulted, but even if not, the larva ceased to feed when it came in contact with the dirt-contaminated pollen. If the pollen ball dried a little too much, the larva refused to feed and died. If the spherical pollen ball was deformed in being removed from the cell, the same thing occurred. It should not be surprising that I have the impression that *C. andreniformis* is a sensitive, fastidious species.

To cope with these difficulties, the following techniques were used successfully. A petri dish was designed to serve as a receiving vessel for immature specimens in the field. The lower half of a standard petri dish was half-filled with melted beeswax (paraffin did not give sufficient friction for this surface). A flat piece of galvanized sheet metal was cut to form a V-point, the angle of the V such that a pollen ball resting in the conical cut made in the wax by this tool would be supported at or below its middle. The V-point was simply pressed lightly into the solidified beeswax and slowly turned to give the necessary conical excavation. Other cone-shaped depressions were sunk deeper to receive water which maintained the pollen balls at their proper moisture during their time in the field. It was necessary to shade the petri collection dish for otherwise the temperature would have risen high enough to kill the specimens.

A device was made to remove pollen balls with no resulting distortion of shape. A circular loop 1.5 mm in diameter was formed at the end of each of two number one stainless steel insect pins whose heads were removed. These were cemented to the tips of a pair of fine forceps with the planes of the loops parallel to each other and to the sides of the forceps. This afforded such steady handling that moisture condensate could be blotted with ease from the bottom of the pollen ball with lens tissue during transfer from nest cell to petri collection dish. Once set in the conical depression, the pollen ball did not shift in orientation. Larvae suddenly exhumed from complete darkness into full sunlight continued to consume pollen normally.

Pollen balls kept in a closed container of 93% relative humidity (saturated solution of $NH_4H_2PO_4$), with daytime temperature 30°C, dropping to 18°C nightly, shrunk in diameter from 2.83 mm to 2.50 mm in 48 hours. The feeding larva contracted, became motionless, and mold growth began in 24 more hours.

Pollen balls with eggs or early larvae kept in a closed container at 100% relative humidity (distilled water) and 30°C did well until a sudden drop in

room temperature precipitated moisture on them. This invariably resulted in cessation of feeding and mold formation shortly thereafter. Mold formation followed cessation of feeding in so many instances that I am led to speculate that there may be a cause and effect relationship. Why should moisture condensate in the laboratory disrupt feeding when obviously moisture condensate in the cell in the field does not do so? The answer may lie in the kind of container I used: a flat-topped one. The plane surface allowed coalescence of condensate and several *large* drops fell on top of the pollen ball and larva. In the rounded, waxed cell, moisture condensate rolled down the rounded sides of the cell and collected around the bottom of the pollen ball; neither pollen ball above nor specimen were wetted. Had I copied nature in making a waxed, domed roof for my rearing chamber at high humidity I would perhaps have been successful in carrying through these early stages which require such high humidity, yet apparently cannot stand moisture condensing directly on them. Gaseous mold inhibitors, or possibly a fine film of a liquid one applied to the pollen ball, would probably defeat the mold problem.

Daily Activity. Daily activity was dependent primarily on soil moisture, soil temperature, and air temperature. If the ground was soaked, the bees stayed in their burrows even though the weather was very good. Obviously they could not struggle through the mud. Although the greatest number of *andreniformis* were on the wing when the weather was clear and bright, many of them collected pollen on days when the light level was down to 860 milliphots in contrast to 8600 to 12,900 milliphots on the best days. Cloudy weather, even complete overcast (30 milliphots), did not make them cease activity altogether. Possibly they could sense a real storm coming, for I never saw any of them working just prior to a downpour. Both males and females spend much time at the nesting site, flying about and landing here and there. Their antennae are held straight and move side-to-side in tandem, or to and fro when they settle in the area. The female ventures only a short distance from her burrow on the day after digging it. This seems strange because she has apparently gotten thoroughly acquainted with the area around it by actually walking over it time and time again before deciding just exactly what spot suits her. She is often seen to push her head and part of her thorax out through the tumulus and remain there moving her antenna. She eventually emerges but may do nothing more than walk around the tumulus scratching about like a cat. She may come out and immediately go back in. After the first day following burrow construction, the female may fly out of the area, presumably on foraging flights. A common action was noticed by Ainslie (1937), and anyone studying females at the nest will soon see it again and again; females often fly immediately above the ground surface if it is bare, and they create little whirlwinds of dust with their rapidly vibrating wings. Upon leaving their nests they may hover a few mm above the

tumulus in the manner of hover flies, pivoting slowly about the tumuli, then fly one or two somewhat circular patterns over the tumuli and fly out of the area.

The female's orientation flight upon first leaving the nest in the morning is very short. She bursts quickly through the tumulus, circles a few times at rapidly increasing distances from the nest and is gone. I was never able to follow her closely enough to sketch the motions, but the orientation flight is not intricate.

On returning, she may fly straight to the tumulus or, more usually, she flies back with her pollen load to the general vicinity of the nest and alights here and there. Eventually she goes into her nest. I never saw a female mistaking another female's nest for her own. Related bees such as *Andrena* and *Perdita* may have considerable trouble finding their own nests (Michener and Rettenmeyer, 1956; Michener and Ordway, 1963) and may make errors in entering another's nest before finding their own. Individual female *Calliopsis* nests may have distinctive odors that prevent such errors.

ODOR OF CALLIOPSIS AND ORIENTATION ABOUT THE NESTS. A distinctive odor resembling that of oil of lemongrass (Guenther, 1950) was first noticed when a female *andreniformis* on her first emergence was captured at 9 a.m., July 24, 1957; she secreted a large drop of clear fluid from her mouthparts onto my fingers. Rough handling elicits this odor from females but gentle handling does not do so. Specimens captured with an aerial net impart their lemony scent to the net. I have tried to provoke its release in males but have noticed only the faintest odor from one specimen, a fresh male dug out of its overnight burrow at 6 p.m., May 26, 1958. Dr. J. G. Rozen, Jr., has informed me (1963) that both *C. crypta* and *C. rozeni* give off a lemony odor; they are members of a different subgenus.

The odors of non-*Apis* bees have been a neglected facet of bee biology. G. E. Bohart has told me that his field experience indicates that most genera of solitary bees have distinctive odors. Bees with which a lemon-like odor has been associated are listed in Table 7.

Malyshev (1913) found that Russian *Ceratina* with atrophied stings defend themselves and their nests by secreting "a yellow saliva, vigorously scenting of lemon. If a *Ceratina* is seized across the body with a forceps, it hastily strives to place its fragrant secretion upon the instrument by means of its fore and then middle legs. When the *Ceratina* are expelling earwigs from their nests this odour of lemon . . . is sometimes perceptible."

Moure (1958) described Warwick Kerr's discovery that the meliponid bee *Lestrimelitta limao* uses its scent glands to give off a strong odor of lemon which is used to invade and rob the nests of the meliponine bees, *Trigona emerina, remota,* and *testaceicornis*. The strong lemony odor "overpowered the normal odor of the nest. . . . Once the robbed colony has lost control of

Table 7. Bees Which Produce a Lemon-like Odor

Author	Odor	Locality	Bee
Shuckard (1866)	Citron	England	*Prosopis (=Hylaeus)*
Ferton (1901)	Vervain	France	*Colletes*
	= lemony		*Prosopis (=Hylaeus)*
			Andrena
			Panurgus
Malyshev (1913)	Lemon	Russia	*Ceratina*
Schwarz (1948)	Lemon-like	Central & South America	*Trigona testaccicornis*
			Lestrimelitta limao
Shinn	Oil of Lemongrass; Citral	Colorado	*Calliopsis teucrii*
		Kansas	*C. andreniformis*
		Tennessee	*C. andreniformis*
		Texas	*C. andreniformis*
	Rank Oil of Lemongrass	Colorado	*Nomadopsis scitula scitula*
Moure (1958)	Lemon	Brazil	*Lestrimelitta limao*
Kullenberg (1953)	Lemon scent: citronellol-geraniol-citral	Sweden	*Prosopis (=Hylaeus)*
			Halictus
			Heriades
			Megachile
			Andrena
			Nomada
			Apis mellifera (Italian)
Rozen (1963)	Lemon	Arizona	*Calliopsis crypta*
			Calliopsis rozeni
Rozen (1965a)	Lemon	Switzerland	*Melitturga clavicornis*
Weaver, Weaver, and Law (1964)	Geraniol-Citral	Texas	*Apis mellifera*

the odor, the *Lestrimelitta* workers can enter and leave freely. . . . (the lemony odor) seems to be the important factor in orienting the arrival of the robbers, guiding them to the correct entrance, even if other nest entrances are close by. . . ."

The above references then give three functions for the lemony odor: defense; offense; guidance towards location of others of their group. The first function is likely in *andreniformis* as indicated above, and I suspect the presence of the last. The tumuli of the females have this odor, and it may be a factor which influences the bees to build their nests in aggregations. Most females have no trouble finding their own nests, even though several other entrances may be only an inch or so away. A female may plunge straight into her tumulus, dig furiously downward, and disappear in a few seconds.

To test whether she detected her individual scent spectrum at close quarters to the tumulus, I performed the following experiments. Each individual

of a number of pairs of bees which nested very close together in the East Stake plot was differentially marked. A period was chosen when two bees of a pair having tumuli of similar size left their nests. Then the tumuli were exchanged and arranged approximately as found. When a female returned to the nest, she exhibited one of five actions:

(1) Flew directly to her nest with neighbor's tumulus, dug down and deposited pollen in the nest as though undisturbed by the exchange of tumuli: 5 individuals.

(2) Flew directly to her nest with neighbor's tumulus, but was disturbed, buzzed around tumulus and adjacent tumuli, and dug into her true tumulus over neighbor's nest, but came right up again. Found her own nest after flying around, deposited pollen load in nest: 4 individuals.

(3) Same as (2), except dug into several tumuli including her own, taking more than 10 minutes to find her own nest: 1 individual.

(4) Came into area, settled nearby (usually about a foot distant from her nest), made several sorties over tumuli including her own, then landed on hers. Dug right in, but came up again. Flew away, returned to her nest with neighbor's tumulus over it, dug down, deposited pollen: 4 individuals.

(5) Came into area without pollen, investigated several tumuli, left area; back in the proper nest the next morning (1 individual never returned): 3 individuals.

To the five individuals of (1), and the one of (3) a scented tumulus was unimportant in finding their true burrows. To the four specimens of (2), and the four specimens of (4) odor apparently played a part in the decision as to which tumulus was theirs, but the real test was whether the burrow itself was theirs or not. If not, they did not deposit pollen in it. Unfortunately, exactly the right conditions for this experiment were rarely encountered, and more trials will be necessary to draw definite conclusions.

Apparently landmarks are important to *andreniformis* in finding its own burrow, but it also seems likely from these trials that scent sometimes plays a role when the bee alights on the tumulus. I think it possible that some bees depend more upon physical-object orientation at close range, while others pay more heed to the scent of the tumulus. The males return to their same burrows night after night in some cases, and their tumulus is apparently unscented. It is possible that odor may also function as a sex attractant, but I have no evidence for such a role.

Newly emerged females in the laboratory give off the scent; males do not. If it were directly from their pollen ball or nectar, the males would be expected to furnish the scent, too. The one male that gave a very faint scent may have been scented by a female.

C. andreniformis uses the nectar of *Verbena,* which possesses the lemon-odored citral in its pollen and leaves (Guenther, 1952), but the clovers used

for pollen and nectar lack terpenes whose odors resemble citral. The odor of *C. andreniformis* is also reminiscent of citronellol and citronellal. The last two compounds are not widespread among plants, but it is not impossible that any of the three compounds could result from the bee's metabolic breakdown of products present in clover. Citronellol in crocodile musk has been attributed to the breakdown of cholesterol.

Although the terpenes above are powerful scents which diffuse quickly, female tumuli at the West Stake plot continued to give the odor for more than two weeks (not tested after that length of time). A cat and dog repellent, Chaperone(R), whose principal active ingredient is oil of lemongrass, persists this long on soil or longer when applied to garbage cans which are left out in the sun and rain.

Flower Relationships. Robertson (1929) listed 51 species of flowers visited by *Calliopsis andreniformis* at Carlinville, Illinois. It has been taken on flowers of 98 species in all. It is certain, however, that a fair number of the records from the literature and specimen labels are for flowers that play little or no role in the ecology of the bee.

In general, *andreniformis* gathers pollen and sucks nectar primarily from species of Leguminosae, Compositae, Verbenaceae, Oxalidaceae, and Malvaceae, in descending order of frequency of use according to my observations. The last family is especially favored in the salt marsh areas of southern New Jersey where both *Malva rotundifolia* and *M. neglecta* are abundant.

In visiting flowers of *Trifolium, Lespedeza, Psoralea,* and *Melilotus,* the bee holds onto the wings of the legume blossom with its feet, slides the frons down against the standard, and thrusts the proboscis into the flower to get the nectar. Pollen is carried by the females on the hind tibiae exclusively; I have not observed the method of collecting the pollen. Flight ranges are usually short because the bee picks the closest suitable nesting site to its flower. They will fly at least 45 m from their nest in search of pollen, and they probably fly farther if their source of pollen is destroyed.

Flowers used by *andreniformis* as determined by direct observation or by examination of pollen loads or pollen balls are listed in Table 8 and include Robertson's (1929) records as well as any others where the nature of the visit to the flower is stated. The composition of the loads of pollen was examined for only 17 specimens—too few for generalization. These 17 pollen loads were of all Leguminosae, all Malvaceae, or mixed Malvaceae-Compositae.

Both male and female bees feed on pollen. Taniguchi (1956) records this habit for Japanese *Andrena,* and Michener and Rettenmeyer (1956) state that the females of *A. erythronii* regularly eat pollen. The species was never seen to suck up dew, and their water requirement is probably met by nectar collection.

TABLE 8. Known Pollen Sources of Female *Calliopsis andreniformis*

FAMILY	SPECIES
COMPOSITAE*	*Aster ericoides villosus*
	Erigeron canadensis
	Verbesina helianthoides
CONVOLVULACEAE	*Convolvulus sp.*
LABIATAE	*Lycopus sinuatus*
	Pycnanthemum pilosum
LEGUMINOSAE*	*Desmodium marilandicum*
	Desmodium paniculatum
	Melitotus alba
	Melitotus officinalis
	Psoralea onybrychis
	Trifolium procumbens
	Trifolium repens
	Trifolium pratense
LYTHRACEAE	*Lythrum alatum*
MALVACEAE*	*Malva neglecta*
	M. rotundifolia
OXALIDACEAE	*Oxalis stricta*
POLYGALACEAE	*Polygala sanguinea*
POLYGONACEAE	*Polygonum buxiforme*
RUBIACEAE	*Hedyotis purpurea*
SCROPHULARIACEAE	*Gerardia tenuifolia*
VERBENACEAE*	*Lippia lanceolata*
	Verbena bracteata
	Verbena hastata
	Verbena urticifolia

* These families are the most important pollen sources.

The emerging overwintering generation depends largely on *Trifolium repens, T. procumbens, Melilotus officinalis,* and *Verbena bracteata* for its foraging. These plants begin blooming in early May. By about the first week in June *Psoralea, Polygonum, Erigeron,* and *Convolvulus* are in use for pollen and nectar. By the middle of June *Melilotus alba* and *Oxalis stricta* are flowering and are used for pollen and nectar. The second generation visits mostly *Trifolium repens* and *Melilotus alba,* as do any third generation bees which may emerge (rare). I never saw *andreniformis* make any visits to the numerous flowers of *Taraxacum officinalis* which bloomed in the vicinity of every nest site I observed.

SOCIAL PARASITES. The social parasites most in evidence at all localities where nest sites were located were bees of the genus *Holcopasites.* These ubiquitous parasites have been reported by Ainslie (1937) to parasitize *C. andreniformis. Holcopasites calliopsidis* parasitizes *andreniformis* at Lawrence, Kansas; Nacogdoches, Texas; Knoxville, Tennessee; and apparently in

Iowa and Illinois. Here recorded for the first time is the fact that *Holcopasites illinoiensis* (determination by P. D. Hurd, Jr.) parasitizes *C. andreniformis* during the same period as *H. calliopsidis* does, at Nacogdoches, Texas.

Since there are only three species of *Calliopsis* in the eastern United States, and there are as many as 13 species of *Holcopasites* (Muesebeck, Krombein, and Townes, 1951), it seems likely that some of the species will be found to parasitize other panurgine bees closely related to *Calliopsis*. Linsley, MacSwain, and Smith (1956) reported the association of *H. arizonicus* with a *Pseudopanurgus* in Mexico; I reported (Shinn, 1965) P. D. Hurd's record of the association of this species with *Calliopsis pectidis* in Arizona; and Rozen (1965b) reported the strong likelihood that this species parasitizes *Pseudopanurgus* in Arizona. He also reported finding larvae of *H. knulli* in nests of *C. crypta* and suggested that it also attacks *C. rozeni*.

Despite excavations of nests of *C. andreniformis* which had been repeatedly visited by *H. calliopsidis*, I failed to find the eggs of the parasite. Rozen (1965b) found the eggs of *H. knulli* inserted at an angle under a U-shaped flap of the cell wall in the cells of *C. crypta* and *Pseudopanurgus aethiops*. Most of the eggs were positioned in the roof or side of the cell.

At some of the nesting sites *H. calliopsidis* emerged at the same time as the first *andreniformis* males, but at others it emerged 7-10 days later. Males and females appeared virtually simultaneously. The species disappeared from nesting sites about the time that the bulk of female *andreniformis* disappeared. I have seen no individuals persist as late as some of the female host bees, which may live well into September. Possibly *calliopsidis* never has more than two generations, whereas *andreniformis* may have a weak third or fourth generation, depending upon latitude.

H. calliopsidis spends much time walking around the *andreniformis* nest sites. It walks in a singular fashion; *Holcopasites* is the only known bee which tucks its wings between metasoma and legs and drags them in the dust as it busily examines the ground. I believe this is the first notice of this unusual habit. Rozen (1965b) described *H. arizonicus*, *H. insoletus*, and *H. knulli* as flying slowly over the nesting sites, stopping frequently on tumuli or at the edges of stones under which there might be burrow entrances. This difference in behavior from that of *H. calliopsidis* may be a species difference or possibly a function of the density of nests.

H. calliopsidis flew over the nest sites with seemingly little regard for the presence of *andreniformis* females. It would occasionally arrive at a tumulus simultaneously with a female *andreniformis*. No conflict was observed, but *andreniformis* preceded *calliopsidis* into the burrow. The male *andreniformis* does not tolerate the presence of *calliopsidis*. It chases the latter out of its area.

The female *calliopsidis* burrows down through the host's tumulus and may spend as much as half an hour inside. On several occasions (at least 5),

the female *andreniformis* returned and entered the nest during this time, but there was no indication of combat. The pollen-laden *andreniformis* spent the necessary time unloading pollen, emerged for another pollen-collecting trip, and the *calliopsidis* subsequently emerged.

In the light of Rozen's (1965b) observations that *Holcopasites* lays its eggs before *Calliopsis* provisions its cells, it would be interesting to determine if adult females of *Holcopasites* eat pollen from partially provisioned cells of *Calliopsis*. This might explain some of the long underground stays I recorded for *H. calliopsidis*.

The developmental time for *calliopsidis* may be shorter than that of *andreniformis* because in two nests the shallower cells contained fully fed larvae of *Calliopsis* which had not yet defecated while three deeper cells contained prepupae of *Holcopasites*.

H. calliopsidis has much longer diurnal flight activity than *andreniformis*. It flies from 8 a.m. to 6:30 p.m., whereas *andreniformis* is on the wing from about 8:30 a.m. to 4:00 p.m. Part of this difference in time is spent by the females of *andreniformis* in digging their burrows. The total active hours of *andreniformis* are greater than *calliopsidis*, because the former often continues digging until 8 p.m.

At least 30% of the nest burrows in the West Stake plot (Fig. 146) were visited by *calliopsidis*, but less than 4% of all the dug cells of *andreniformis* contained *calliopsidis* larvae (Table 10). Apparently many visits are made before *calliopsidis* finds a cell suitable for laying her egg. A single female may briefly visit several nests repeatedly—a few seconds each—before remaining underground in one of them for a longer time of a minute or more.

Frequent mating of *Holcopasites* took place at the *Calliopsis* nesting sites. I never saw mating attempts on flowers. The male calmly mounted the female, which did not struggle to escape, and copulation lasted 1-2 minutes on the ground, the female not attempting to fly. At each nesting site the parasites were readily netted and were marked with quick-drying colored airplane dope. They returned repeatedly to the same site, but ten of twenty marked at the Gym Area disappeared within a week's time. Possibly they disperse to other nesting sites.

Dr. Howell V. Daly found a few *calliopsidis* asleep at 6 p.m., July 14, 1957, on the acuminate tips of the grass, *Setaria glauca* (det. R. N. McGregor) on The University of Kansas campus. They slept holding by their mandibles alone, their wings tucked between the metasomal sternum and hind legs (Fig. 156). Rozen (1965b) described the same sleeping position for *H. insoletus* and *knulli*. The depth of sleep in *calliopsidis* was such as to permit the grass plant on which it was sleeping to be dug up and transported 1 km by foot to a laboratory for photographing without disturbing the bee. More

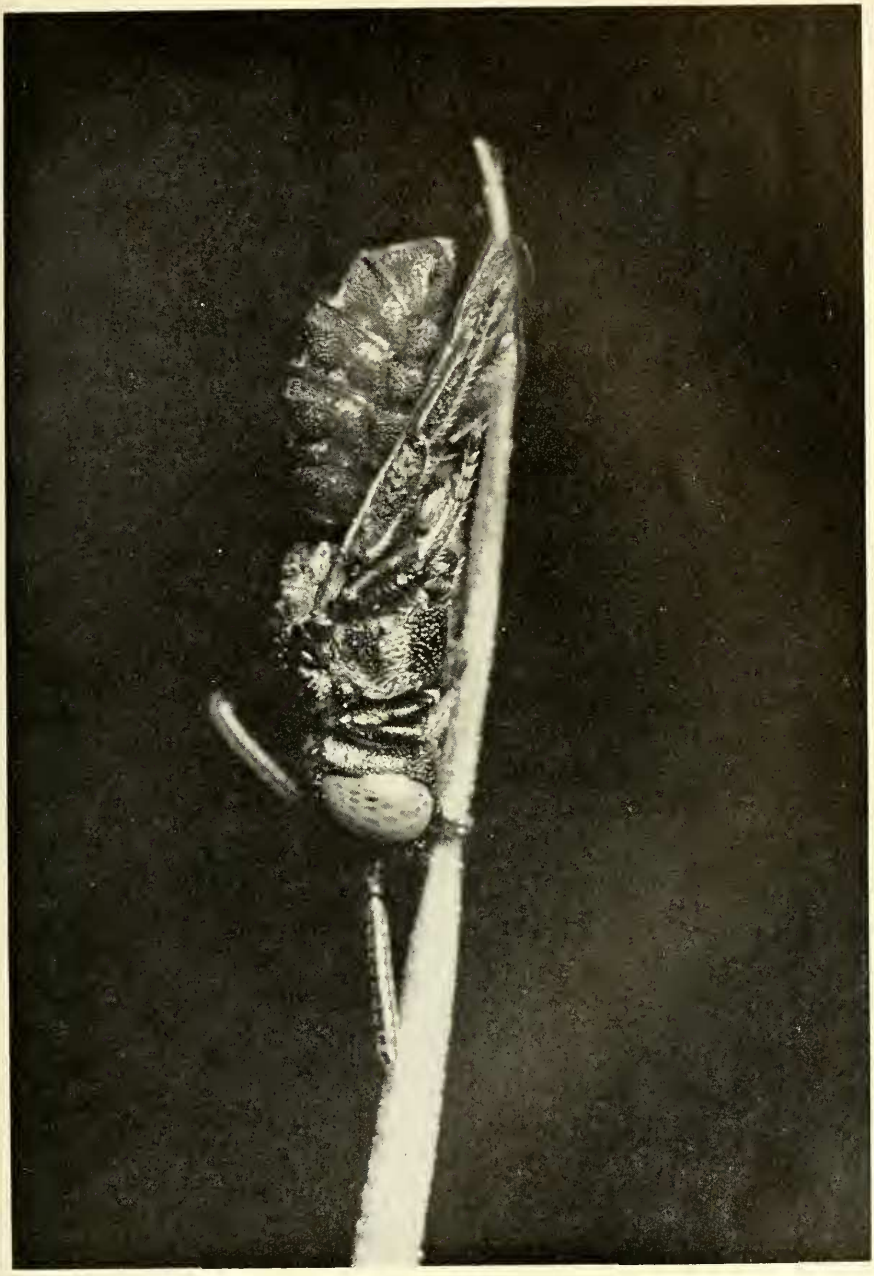

Fig. 156. Photograph of *Holcopasites calliopsidis* asleep on the upright, acuminate tip of a blade of the grass *Setaria glauca*. Note the characteristic position of the wing which lies between the hind leg and the metasomal sternum.

than a dozen *calliopsidis* bees which I marked with colored paints returned to sleep in the same vicinity, sometimes on the same blade of grass.

Sphecodes bees were found at every nesting site I studied. They were much scarcer than *Holcopasites,* but I made no quantitative comparisons. They investigated the *andreniformis* burrows and entered them, staying as long as ten minutes (14 timings, mean 4.86 ± 1.015). I found no larval *Sphecodes* in any *andreniformis* cell; however, the larva from a cell of *andreniformis* described as that of *Holcopasites* by Michener (1953a) is totally unlike that of other pasitine bees, and Dr. J. G. Rozen, Jr., *(in litt.)* considers it to be a *Sphecodes.* There is therefore little doubt that *Sphecodes* does parasitize *Calliopsis.*

At the Stake nest plots two sizes of *Sphecodes* were present and were presumably two species. Both visited the *Calliopsis* burrows, although the smaller one made most of its visits to *Lasioglossum* nests in the area. Mitchell (1956) suspected that *Sphecodes brachycephalus* is a probable parasite of *C. andreniformis.* He also writes (1960) that his personal observations in nesting areas suggest both *Calliopsis* and *Perdita* as hosts for *Sphecodes.* Ainslie (1937) observed *Sphecodes* flying around and active in nest sites of *C. andreniformis* at Sioux City, Iowa. Rau and Rau (1916) found *Sphecodes* sp. in constant attendance at the nest sites of *Calliopsis nebraskensis* near St. Louis, Missouri, and considered them as visitors to the nests.

Villa sinuosa and *Parabombylius ater* were the only bee flies whose actions suggested that they were parasites of *C. andreniformis.* The former was rare, but the latter was a frequent visitor at the Kansas nesting sites and was very abundant at the Texas nesting sites. Several bombyliid larvae were excavated from *andreniformis* cells, but none pupated.

Several counts of *P. ater* were made. On July 4 and July 16, 1957, five and seven individuals were simultaneously active in the West Stake nest plot, or one per 5.1 m^2 and one per 3.6 m^2, respectively. At the Stadium nesting site in Texas on May 10, 15, and 17, 1962, there were 12, 16, and 20 individuals simultaneously active in an area of comparable size, or one per 18.6, 14.8, and 12.0 m^2, respectively. The bee flies hover about 25 mm from a nest whose tumulus has been removed, and they flick tiny white eggs into the exposed burrow entrance. Presumably the larva burrows down through the dirt-filled upper portion of the nest entrance, enters a cell and eats pollen and *Calliopsis* larva, for cells containing bee fly larvae have no traces of anything else in them. *Parabombylius ater* appears about the same time as *C. andreniformis;* its peak of abundance is about coincident with mid-season for its host, and its population appears to drop sharply after this. I interpret this to mean that it has only one generation in Kansas. The fact that several larval specimens dug up in early June did not metamorphose, whereas prepupal *Calliopsis* did, tends to support this interpretation.

Other Associates. The pyemotid mite, *Trochometridium tribulatum* (Cross, 1965) was discovered in two cells of one nest on The University of Kansas campus. Both fungus and pollen were present in these cells. No traces of the bee larvae were found. Krombein (1961) points out that several families of mites contain species that are parasites of solitary wasps and bees, and that several species of *Pyemotes* kill and feed on the more or less helpless immature stages of many insects. This may be the case with *Trochometridium*.

The mites were collected July 22, 1957, from cells 73 and 90 mm below ground level from a block of soil which had been recently brought to the laboratory. Several hundred mites were in the two cells taken together. A huge gravid female was in one cell and almost all the mites were in the egg stage. The mites were transferred to a covered Syracuse dish for observation at room temperature (29.5°C). On July 23, most of the mites were in a ball, but four walking specimens had appeared. On July 24, twelve walking females were present, and on July 25 two males appeared. Females were distinguished from males by a straight white line on the dorsum, by their smooth contour in lateral view, by their more elongate form, and their smoother locomotion. The male bore a broader white line on the dorsum with several strong constrictions along its border, exhibited a posterodorsal tubercle in lateral view, was broadly oval in outline, and moved slowly and clumsily. Its locomotion was mostly by means of the middle two pairs of legs, for the front and hind pairs were borne aloft. By July 27 most eggs had hatched, but mold was forming on the unhatched eggs. Only a few males had appeared, the bulk of the specimens being females. Inasmuch as Dr. Earle A. Cross had recognized them as a new genus and species, the specimens were preserved on July 27. Ainslie (1937) found larvae of *C. andreniformis* infested with mites of the genus *Pygmephorus* (=*Pigmeophorus* Banks, 1904) as determined by H. E. Ewing. He gave no estimate of the extent of the infestation, but I infer it was relatively minor. Crandall and Tate (1947) state that late in the season of *C. andreniformis* at Lincoln, Nebraska, ". . . many of the cells containing larvae were infested with mites. . . ." They listed the mites as: *Pediculoides americanus* (Banks) and *Tyrophagus* sp., both determined by E. W. Baker, and *Lohmannia* sp., determined by H. E. Ewing.

Three species of fungi were identified from prepupal *C. andreniformis: Penicillium cyclopium, Aspergillus flavipes,* and *A. sydowi.* Dr. Robert Lichtwardt kindly determined the molds. The molds came from specimens in the soil block discussed above, from the West Stake plot, and from specimens reared in the laboratory. Only bees in the rearing boxes kept at 88% relative humidity (maintained by $BaCl_2$ solution) and above developed mold

TABLE 9. Contents of *Calliopsis andreniformis* Cells Dug During Summer and Early Autumn

	Number	*Percentage*
C. andreniformis, live, immature	192	77.4
C. *andreniformis,* dead, moldy, immature	22	8.9
Empty, waxed cells	12	4.8
Holcopasites or *Sphecodes,* prepupae	10	4.0
Beeflies, larvae	8	3.2
Mites, *Trochometridium tribulatum*	4	1.6
Totals	248	99.9

growth. Two bee fly larvae, surrounded by moldy bee prepupae, did not support a mold growth.

Penicillium cyclopium is worldwide and found on many different substrates, for example, rotting bulbs of Liliaceae, mildewing tentage, soil and decaying vegetation, and in bee hives (Raper and Thom, 1949). Both *Aspergillus* species are cosmopolitan. *A. flavipes* is particularly common in soil and decomposing organic materials, and *A. sydowi* is known from soil of several eastern states and from beehives in Michigan (Thom and Raper, 1945).

A small asilid fly was present at three nest sites at Lawrence, Kansas. It looked remarkably like a female of *C. andreniformis* and acted and flew like the female as well. Its only known prey were two male *andreniformis,* which tempts speculation that it may be aided in obtaining its prey by its superficial resemblance to the female.

Although the bee-predator wasps of the genus *Philanthus* were seen about the West Stake nesting plot as well as several others, they were never seen to take *andreniformis,* or for that matter, any prey. Reinhard (1924) records *Philanthus gibbosus* as using *andreniformis* for prey: *Philanthus* cells yielded 1 female and 5 males of *andreniformis* and 325 specimens of halictid bees. It seems that *andreniformis,* representing only 1.8% of the prey of *Philanthus,* could well be considered as accidental prey. *Philanthus* captures its prey on flowers, and a list of flowers given by Reinhard as used by *P. gibbosus* includes some flowers used by *andreniformis: Achillea millefolium, Erigeron,* and *Polygonum.* These flowers are rarely used by *andreniformis,* but much by Halictidae. This, too, lends support to my supposition that *andreniformis* is an exceptional prey for *P. gibbosus* rather than one that is customarily used at a low percentage.

A *Nysson* wasp was much in evidence about *andreniformis* nests at the West Stake plot, often entering nests, but never emerging with any plundered prey or external evidence of pollen. Rau (1922) recorded the entrance of

Nysson ratti into the burrow of *C. (Verbenapis) nebraskensis*. I have no other observations about the wasps' action in connection with *andreniformis* nests.

White podurid collembolans were sometimes found in nests. A clamydid beetle larva which encases itself in a mud cocoon occasionally spent the night in burrows whose upper portions were free of loose, excavated dirt.

Table 9 lists the contents of cells from apparently completed nests which were dug during summer and autumn.

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